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Meat and Poultry Plants' Food Safety Investments

Survey Findings

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Meat and Poultry Plants' Food Safety Investments: Survey Findings

Michael Ollinger, Danna Moore, and Ram Chandran

Abstract

Results from the first national survey of the types and amounts of food safety investments made by meat and poultry slaughter and processing plants since the late 1990s provide evidence that market forces have worked in conjunction with regulation to promote the use of more sophisticated food safety technologies. From 1996 through 2000, U.S. plants as a group spent about $380 million annually and made $570 million in long-term investments to comply with USDA's 1996 Pathogen Reduction/Hazard Analysis and Critical Control Point (PR/HACCP) regulation, according to a survey initiated by the Economic Research Service. The U.S. meat and poultry industry as a whole during the same time period spent an additional $360 million on food safety investments that were not required by the PR/HACCP rule. Implementation of the regulation began in 1997 and was mandated by early 2000 in all sizes and types of meat and poultry slaughter and processing plants.

The full HACCP surveys referenced in this technical bulletin are available at: www.ers.usda.gov/data/haccpsurvey.

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About the Authors

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Summary

From 1996 through 2000, U.S. meat and poultry slaughtering and processing plants as a group spent about $380 million annually and made $570 million in long-term investments to comply with USDA's 1996 Pathogen Reduction/Hazard Analysis and Critical Control Point (PR/HACCP) regulation, according to an Economic Research Service/Washington State University survey. The entire U.S. meat and poultry industry during the same time period spent an additional $360 million on long-term food safety investments that were not required by the PR/HACCP rule.

Averaged out over 1996-2000, the industry's private and HACCP-required long-term investments of $930 million came to about $180 million per year. That average amounted to about 10 percent of the $1.8 billion the U.S. meat and poultry industry spent in total investments annually over that period, according to the Census of Manufacturers (U.S. Department of Commerce, 1999a, 1999b, 1999c).

The industry's annual investments in food safety measures are much higher than the cost estimates made by USDA's Food Safety and Inspection Service (FSIS) prior to enactment of the regulation. FSIS estimated the U.S. meat and poultry industry as a whole would spend less than $50 million per year to comply with the PR/HACCP regulation, or $1 billion to $1.2 billion spread over 20 years. ERS research projected the U.S. meat and poultry industry would spend $623 million annually to comply with the regulation. Even with the higher cost estimate, projected health benefits still exceed industry costs. A 1997 ERS study estimated benefits of $1.9 billion in annual health cost savings linked with a reduction in foodborne illness due to implementation of food safety technologies and PR/HACCP procedures (Crutchfield, 1997).

One reason for the disparity between the FSIS and ERS cost figures is that FSIS considered only administrative costs: recordkeeping, planning, testing, and capital outlays. The ERS analysis included those costs as well as the costs of hiring the workers necessary to remain in regulatory compliance, and the additional capital outlays necessary to bring each plant up to the standards necessary for regulatory compliance.

The annual cost of HACCP compliance amounts to less than 1 percent of the cost of meat and poultry products, an ERS analysis of survey data shows. The PR/HACCP rule has raised beef and poultry slaughter plant costs by about one-third of 1 cent per pound, the data suggest. These are average prices per pound of beef and not the average cost incurred by each plant. Small plants, which tend to produce more specialized products, had much higher average costs than the giant plants, which produce mainly commodity products, such as boxed beef. Since plants must recover their costs, this means that prices for commodity products will rise very little, while prices for more specialized products, like cut-to-order beef, may rise as much as 2 or 3 cents per pound. It also means that small plants competing in commodity markets may find it more difficult to remain in business.

Designed and funded by ERS and conducted by Washington State University's Social and Economic Sciences Research Center (SESRC) in

early 2001, the survey is the first national one to examine the effects of the PR/HACCP rule and of private markets on plant costs and food safety technology use since the regulation went into effect. The ERS analysis of survey results focused primarily on the extent to which meat and poultry plants have been encouraged to adopt and use new food safety technologies and practices to control pathogens. Meat and poultry plants made significant new investments to comply with the PR/HACCP rule. However, market forces were also at work, encouraging the use of more sophisticated food safety technologies and an expanded array of food safety practices and boosting investments by plants beyond those required by the PR/HACCP regulation.

The survey data show that a meat or poultry plant's choice of food safety technology was strongly influenced by the plant's size and the strength of its market incentives. Large plants favored equipment and testing technologies; small plants relied more on manual sanitation and adjusting plant operations. U.S. plants that exported products and were subject to food safety requirements by those customers, among others, made greater investments in food safety operations across a range of technologies than plants that did not export products to other countries.

The 1996 PR/HACCP rule shifted emphasis from visual inspection of carcasses to control of pathogens using a system of checks at critical control points where food safety is at risk, required plant operators to conduct tests for generic *Escherichia coli* (*E. coli*), and imposed *Salmonella* performance standards. Implementation of the regulation began in 1997 and was mandated by early 2000 in all sizes and types of meat and poultry slaughter and processing plants in the United States.

In conducting the survey, SESRC sent surveys to 1,725 plants classified as cattle, hog, or poultry slaughter plants or cooked or raw meat processing plants with no slaughter operations. Of the original 1,725 plants, representatives from 996 plants completed surveys and returned them to SESRC. The survey plants ranged in size from establishments with only a handful of workers slaughtering 1 or 2 animals per week to ones with more than 1,000 workers and producing millions of pounds of product per year. The survey questions and frequency of responses can be accessed on the ERS website at www.ers.usda.gov/data/haccpsurvey.

Introduction

Today, both government food safety agencies and private markets have roles to play in ensuring a safe supply of meat and poultry. The Federal Government, through the U.S. Department of Agriculture's Food Safety and Inspection Service (FSIS), inspects all animals for human consumption for animal diseases and monitors processing and slaughtering plants to ensure that they process meat in a sanitary fashion. Private markets provide added incentives to produce safe meat and poultry products.

The purpose of this report is to examine the economic forces affecting food safety expenditures, equipment use, and practices in the meat and poultry slaughter and processing industries. More specifically, we consider the costs of the 1996 Pathogen Reduction/Hazard Analysis and Critical Control Point (PR/HACCP) rule and how this regulation and private markets encourage the use of food safety technologies and practices to control pathogens.

This report uses the first national survey of meat and poultry plants on the costs of the PR/HACCP rule and the use of food safety technologies. USDA's Economic Research Service (ERS) initiated this project in order to obtain data that is important to achieving a better understanding of how the complex mix of technology, private markets, and government regulation interact to provide safe and wholesome meat and poultry products. The survey was implemented by Washington State University (WSU) and completed in May 2002. Altogether, nearly 1,000 plants responded to a survey that was sent to all meat and poultry slaughter and processing plants deemed to be mainly manufacturers and inspected by FSIS. The survey included about 15 questions on the costs and benefits of the PR/HACCP rule and about 35 questions on food safety technologies and practices in the meat and poultry industries. The remaining questions dealt with plant characteristics. The complete survey and the summary data are found on the ERS website at www.ers.usda.gov/data/haccpsurvey.

We first develop a model of how the incentives provided by private market mechanisms, such as product branding, interact with government regulation to encourage food safety. We then discuss the survey methodology, describe the data, and present results of food safety expenditures and technological choices in the context of our model.

Background

USDA's Food Safety and Inspection Service has enforced the Nation's food safety laws for meat products that move across State lines since 1890 and for poultry since 1957. FSIS began monitoring meat and poultry sanitation and process control activities more closely with enactment of the Wholesome Meat Act of 1967 and the Wholesome Poultry Products Act of 1968. With outbreaks of foodborne illnesses during the 1980s and 1990s, FSIS' emphasis shifted toward the control of harmful pathogens, which cannot be seen by consumers, and away from traditional inspection of animal carcasses for visible signs of diseases.[1] To reflect this new emphasis, FSIS promulgated the PR/HACCP rule on July 25, 1996.

The PR/HACCP rule mandates that each meat and poultry slaughter and processing plant establish and implement standard sanitation operating procedures (SSOPs). These activities are cleaning practices that a plant performs to ensure that it is operating in a clean and sanitary manner. The rule also requires plants to have and adhere to a HACCP plan. Under a HACCP program, plants monitor points in their processing system that have the potential of leading to a food safety hazard and take corrective actions when they suspect that a critical level at one of these points has been breached.

HACCP plans are based on seven criteria:

(1) assess all hazards,

(2) find all points where food safety is at risk (critical control points),

(3) set critical limits for each critical control point (CCP),

(4) develop procedures to monitor each CCP,

(5) determine corrective actions,

(6) implement a record-keeping system, and

(7) establish verification procedures (Unnevehr and Jensen, 1996).

The PR/HACCP rule mandated that all slaughter plants conduct generic *E. coli* testing to ensure the adequacy of their controls. In addition, plants that slaughter animals or produce raw ground products have to adhere to *Salmonella* performance standards. FSIS phased in the PR/HACCP rule over a 3-year span starting in January 1998. The largest plants (those with more than 500 employees) had to comply by the end of January 1998, small plants (10 to 499 employees) had until January 1999, and very small plants (fewer than 10 employees or annual sales less than $2.5 million) had to conform by the end of January 2000. All plants had to have sanitation standard operating procedures (SSOPs) in place by January 1997, regardless of size. (See Ollinger and Mueller (2003) for a more detailed discussion of PR/HACCP and regulations that preceded it.)

[1]Medical experts indicate that foodborne illness outbreaks have always been present. Advances in epidemiology, however, made it possible to identify the sources of illnesses that previously could not be identified. Some of these sources, such as *Salmonella*, have been common for many years while others, such as *E. coli* O157:H7, are a new danger.

Private Markets and Government Regulation Play Roles in Ensuring the Use of Food Safety Process Controls

The quality and characteristics of many food products that we buy can be directly observed. For example, the ripeness of a banana can be determined by its color, and its type can be ascertained from its physical dimensions. For meat products, consumers can use government grading practices, e.g., lean ground meat, and visual observations to compare meat cuts by meat texture, fat content, and type. However, consumers have no accurate way to measure food safety and, thus, may unknowingly purchase and eat products that are contaminated. In some cases, particularly for the elderly and the very young, consumption of contaminated foods may cause serious illnesses and even death.

If an illness outbreak does occur and health authorities are able to link the illness to a particular food, then the sales of all producers of that type of food may be adversely affected. Consumers have many food choices, and, generally, believe each product is safe for consumption. If consumers learn that someone became sick after consuming a particular type of product, then consumers will select a different food product. If the adulterated product has a brand, then consumers will avoid products produced under that brand. However, if the product is unbranded or its source is unknown, then consumers will avoid the purchase of all products of that type, regardless of source, because all products would have the same appearance, and, thus, be potentially harmful.

A loss of consumer confidence in a company's products can be financially devastating. Hudson Foods, for example, exited the hamburger patty business after it was held responsible for the production of hamburgers tainted with *E. coli* O157: H7. For this reason, many companies have sought third-party accreditation of the safety of their meat products. For example, Wiser (1986) asserts that the red meat industry sought food safety legislation between 1890 and 1910 in order to assure export markets of the quality of American meat exports. In recent years, it has been major meat and poultry buyers, such as McDonald's, Burger King, Kroger, and other large fast food restaurants and grocery chains, rather than sellers, that have taken the lead in assuring food safety. These companies recognize that, if they fail to deliver food safety, consumers will stop buying their products. Thus, they enter into long-term contracts with suppliers in which they demand that their supplier adopt the most advanced food safety technologies and practices in exchange for a guaranteed market for their products (Ollinger, 1996). In an informal survey of nine large food retail firms, Kaufman (1994) found that six of the surveyed firms mandated their own safety standards and seven required adherence to either good manufacturing practices (GMPs) or HACCP programs. Food safety quality-control programs required by McDonald's, Jack-in-the-Box, and other fast food chains illustrate that industry's strong commitment to food safety (Ollinger, 1996).

Restaurants, grocery stores, and other buyers and plants are made better off by entering into contractual relationships stipulating higher quality. Buyers benefit because there is a reduced threat of risking a reputation loss stemming

from an outbreak of foodborne illness. For example, Jack-in-the-Box lost millions of dollars due to selling hamburgers tainted with *E. coli* O157:H7. Meat suppliers benefit from increased sales and a more certain market for their products (Golan et al., 2004).

Export markets provide a lucrative outlet for meat suppliers. Recent actions taken by food authorities in Russia, South Korea, and other countries to limit access to their markets have cost U.S. exporters millions of dollars in lost sales and have forced U.S. suppliers to change operating procedures to meet export market demands. Thus, export markets, like buyer requirements, may encourage firms to make investments in food safety process controls.[2]

[2]Some argue that the primary purpose of food safety import standards is to restrict imports rather than enhance food safety. Regardless of the motivation, the standards must be met, and the effect is to improve food safety quality.

Major meat and poultry buyers can evaluate food safety because they know the conditions under which the products were produced and can conduct their own pathogen tests. However, low-volume buyers and consumers do not have such capabilities. Moreover, even if consumers contract foodborne illnesses from contaminated food products, they may not know the quality of the food that caused it because there often is no direct linkage between a sickness and the meat or poultry producer. Several factors account for this:

(1) A buyer may be unable to identify an illness as being due to foodborne pathogens.

(2) Even if a buyer knows that sickness is due to a foodborne pathogen, it may be difficult to determine the specific food that caused it, partly because the evidence has already been consumed.

(3) Although the food may be identified, the place of purchase/consumption may be unknown.

(4) If the place of purchase/consumption is known, the producer of the specific food may be unknown because the store may have bought meat or poultry products from many suppliers, obscuring the producer's identity.

Low-volume buyers and consumers can sometimes identify producers, however. If there is only one supplier of a generic product, then the source can be identified. Market mechanisms too can help identify producers. Branded products typically earn a price premium because of perceived higher quality. Producers use brands to encourage repeat purchases, but brands also enable consumers and food safety experts to identify the source of the pathogen-tainted product that caused the foodborne illness. The expense of a lost reputation for producing contaminated products can be devastating. As reported by Alison Young of the *Detroit Free Press* (6-21-2001), Sara Lee incurred $76 million in direct costs and lost over $200 million in sales after one of its plants was implicated in the production of frankfurters containing *Listeria monocytogenes*. This foodborne pathogen killed at least 15 people, caused 6 miscarriages, and seriously sickened 80 people.

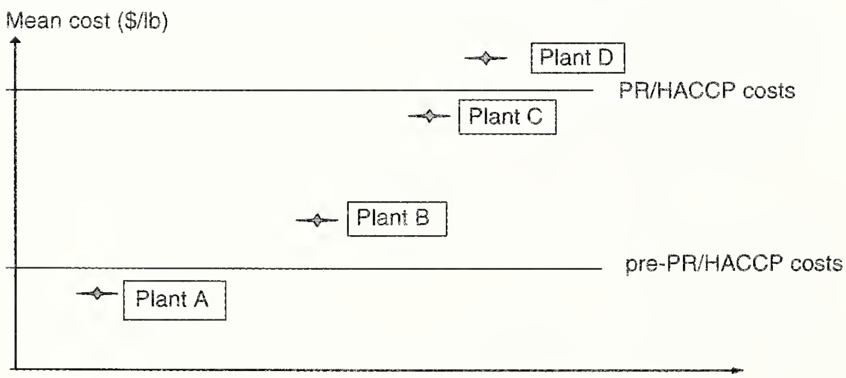
Private Economic Incentives Encourage the Use of Food Safety Process Controls

Markets impose food safety requirements up to the point at which it is no longer profitable to do so, suggesting that plants would perform some food safety process control tasks in the absence of any regulation. However, the strength of the incentive varies by the type of market. Hence, the precise number and comprehensiveness of the tasks necessary to maintain food safety may or may not exceed the number and detail required by FSIS under the 1996 PR/HACCP rule. We illustrate cost-per-pound levels of quality control effort in figure 1 for both a case prior to the PR/HACCP rule and another under the PR/HACCP rule. The cost levels are arbitrarily drawn but do illustrate that mean PR/HACCP costs are equal to or higher than the mean pre-PR/HACCP rule costs. This is true because regulation does not prevent plants from undertaking quality-control actions that they deem necessary and usually requires some tasks that plants would not otherwise perform.[3] We assume that plants would continue to perform tasks that they consider essential but are not required under regulation.

[3]Presumably, plants do not perform some tasks required under regulation because they perceive the private benefits to be less than the costs. There is also an administrative cost to plants in that they must report quality control efforts to the government. In the absence of regulation, there would be no reporting cost.

The stars in figure 1 represent individual plant costs of process control effort per pound of meat or poultry and are hypothetical points that are used only to illustrate that different plants will choose to expend different levels of process control effort and, thus, have differing expenditure levels. For example, plant A expends less effort than the mean level that existed before PR/HACCP, and plants A, B, and C put forth less effort than the mean level of expenditures under PR/HACCP. Only plant D incurs greater process control expenses than the PR/HACCP rule level. Thus, plants A, B, and C would incur positive but different costs in order to comply with PR/HACCP while plant D incurs no regulatory costs. In terms of hypothetical market arrangements, we hypothesize that plant A would represent a plant that sells generic products that are commingled with products from elsewhere by buyers, giving it no identity with the buyer and the weakest incentive to invest in food safety. Plants B, C, and D, on the other hand, represent plants serving export markets, facing buyer requirements, or selling branded products or facing some other market arrangement that encourages the use of more sophisticated food safety techniques. Evidence supporting these hypotheses is provided in later sections.

Figure 1
Hypothetical mean cost per pound expended for food safety process control under PR/HACCP and pre-PR/HACCP



Industry Characteristics

The U.S. meat and poultry slaughter and processing industries had $110 billion in sales in 1997 and ranged from slaughter plants selling only animal carcasses to processors manufacturing ready-to-eat products for home consumption. There are five main types of plants: cattle, hog, and poultry slaughter plants, producers of cooked or otherwise further processed products with no slaughter operations, and grinders and other processors with no slaughter operations.

Census of Manufacturing data show that there were 1,393 plants owned by 1,308 companies slaughtering animals other than poultry in 1997. A little more than one-fourth of the 1,393 plants had fewer than 20 employees. The large number of plants belies much higher four-firm concentration ratios in cattle slaughter and large plant dominance in both cattle and hog slaughter. MacDonald et al. (2000) show that four-firm concentration ratios in cattle and hog slaughter were 71 and 43 percent, and that plants with more than 400 employees accounted for more than 70 percent of the value of shipments in cattle and more than 85 percent of value of shipments in hog slaughter.

The poultry products industry generated about 60 percent of the sales volume of the cattle, hog, and other nonpoultry animal slaughter industry. But, with only 474 plants owned by 259 companies, poultry plants were, on average, larger and more likely to be part of a multi-plant firm than were plants in the red meat industries. Reflecting this larger plant size, Ollinger et al. (2001) show that more than 80 percent of chicken and turkey slaughter output came from plants with more than 400 employees. Despite the greater degree of multi-plant ownership, four-firm concentration ratios were below 50 percent in 1992 (Ollinger et al., 2001).

Raw-meat processing plants grind, marinate, and debone products while not-raw meat processing plants cook, smoke, ferment, or otherwise process meat or poultry. According to the 1997 Census of Manufacturers, there were 1,297 raw meat further processors and cooked, smoked, fermented, or otherwise further processed product processors. Industry concentration was not particularly high. Four-firm concentration ratios in two main categories—pork products, not sausage, and sausage products—were 31 and 38 percents in 1992 (Ollinger et al., 1997). Moreover, the 1,297 plants were owned by 1,150 companies and about one-half the plants had fewer than 20 employees in 1997.

Survey Techniques and Responses

A major stumbling block facing economists who analyze meat and poultry food safety is a lack of data on the types of food safety technologies processing/slaughter plants are using, the types of markets served by the plants, and the costs plants incur to ensure food safety. Given these limitations, USDA's Economic Research Service (ERS) funded a survey of meat and poultry processing plants on their use of various food safety processing practices and technologies and their costs of implementing and complying with the PR/HACCP rule.

Researchers at ERS will use the data to examine the incremental costs of the PR/HACCP rule on meat and poultry plants, the characteristics of plants using particular types of food safety technologies, the impact of various types of food safety technologies and practices on plant costs, the effect of food safety technologies and practices on pathogen reduction, and the food safety technology profile of plants exiting the industry. Economists will be able to cite these results and the statistical information contained in this report to support economic thought dealing with issues surrounding the use of food safety practices.[4]

Techniques

ERS contracted with the Social and Economic Sciences Research Center (SESRC), Washington State University at Pullman, to conduct a survey of meat and poultry plants on their costs of complying with the PR/HACCP rule and their use of food safety equipment, practices, and technologies. After ERS created a questionnaire and received approval to proceed from the Federal Office of Management and Budget (OMB), SESRC fielded a two-part survey consisting of pilot and main studies in late summer 2001. The study was deemed complete in May 2002.

SESRC used some innovative techniques that likely improved response rates.[5] The first step was to verify addresses and, to the extent possible, provide a person's name to whom the survey information could be sent. The survey itself consisted of five contacts made over a 2-month period: a prenotification letter, a survey questionnaire, a followup postcard, a second questionnaire, and a final notice. SESRC sent letters from a high-ranking USDA food safety official and five industry trade associations with the prenotification letter and the first questionnaire to encourage support. The most important innovation, however, was including a $5 incentive with the questionnaire in a package sent to each recipient in the full survey by 2-day priority mail.

OMB stipulated that incentives could only be used if a pilot study demonstrated their effectiveness. As a result, SESRC conducted a pilot study in which it packaged the questionnaire mailings differently for three separate groups in each of the two main industries (meat and poultry). The three mail packages were:

[4]The data cannot be made available directly to economic researchers because of concerns about confidentiality. However, it may be possible to conduct cooperative studies with ERS researchers who would use the data at ERS.

[5]SESRC is under the direction of Dr. Don Dillman, a renowned innovator in survey methodologies. This project was led by Dr. Danna Moore.

(1) questionnaire sent by first-class postage mailing, no money incentive,

(2) questionnaire sent by 2-day priority mail with no money incentive enclosed, and

(3) questionnaire sent by 2-day priority mail with a $5 incentive enclosed.

The response rate for the third option—priority mail plus incentive—was about 20 percent greater than the priority/no incentive option and about 50 percent greater than the first class/no incentive option. The pilot study also showed that the two types of mailings without incentives would not achieve the same response rate as the priority mail plus incentive option even if the savings from their lower postage and incentive costs were used in followup mailings.

The use of letters of support from five meat and poultry industry associations was another innovative feature of the survey. One letter, shown in appendix A, asks operators to provide information that would aid in understanding the true costs and effectiveness of the (FSIS) inspection system in their plants. It adds that the information could help influence or affect the way future changes are made in inspection requirements.

Responses

ERS drew the sample of plants surveyed by SESRC from the 2000 version of FSIS' Enhanced Facilities Database (EFD). The EFD contains a wide variety of detailed data on plant activities for all plants monitored by FSIS. It also contains some information on plants inspected by State inspection agencies. In total, the EFD contains at least some information on the more than 9,000 meat and poultry plants inspected by FSIS and State agencies. The vast majority of these plants produce meat or poultry products as side businesses. Data include the number and types of animals slaughtered, Standard Industrial Classifications, plant sales, whether a plant produced meat or poultry, and categorical data on process types. We also merged pounds of meat production from the 1997 EFD dataset to these data because the 2000 EFD does not have pounds of meat and poultry output.

The population of plants that we drew from the EFD included only the 1,725 plants that produce meat or poultry products as a primary business. These plants consisted mainly of FSIS-inspected plants and included all for-profit meat and poultry slaughter facilities identified for 2000 in the EFD and the largest cooked-meat and raw-meat further processors that were defined in the EFD as meat packers (SIC 2011), meat processors (SIC 2013), or poultry slaughter or processors (SIC 2015). Canned meat and poultry producers were excluded.

Table 1 describes the sample of plants and the respondents by type of production operation—either slaughter or processing. It shows that 996 (58 percent) of all plants responded to the survey. Hog slaughter plants had the highest response rate at 67 percent while chicken slaughter plants had the lowest response rate at 50 percent. Not all plants answered all questions but

plants did complete most questions.[6] Completed questionnaires were returned by plants that slaughtered 42 percent of all cattle, 75 percent of all hogs, 42 percent of all chickens, and 48 percent of all turkeys, and accounted for 55 percent of all processed meat and poultry products from processors with no slaughter operations. The overall survey response rate of 58 percent of all plants was substantially higher than that achieved in recent surveys of much smaller samples of plants by Hooker et al. (1999), who had a less than a 50-percent response rate (41 out of 98 questionnaires) and Boland et al. (2001), who report a 36-percent response rate (18 of 50 questionnaires).

We attribute the relatively high response rate to three factors:

(1) The survey was sponsored by a government agency whose reports are widely read by policymakers and research institutes.

(2) The five major meat and poultry industry associations and the acting undersecretary for food safety wrote letters of support of the survey and were sent to respondents with the questionnaire.

(3) The use of a $5 incentive and 2-day priority mail encouraged survey participation.

Survey Respondents

Survey participants varied substantially both in plant size and types of inputs and outputs. In tables 2-6, we show how plant output in terms of volume and product composition varies by plant size. For each slaughter industry, we include all plants that slaughter a particular animal species, e.g., cattle, regardless of whether that plant also slaughters other animals, e.g., hogs. Thus, the cattle slaughter plant category contains all plants that slaughter cattle, including those that also slaughter hogs. Since the hog slaughter plant category is structured in the same way, plants slaughtering both hogs and cattle are included in each classification.

The size percentile ranking in each of the first five tables is based on total pounds of output as indicated in the survey (see Q41 for output and Q47 and Q49 for output mix for red meat and see Q42 for output and Q48 and Q50 for output mix for poultry). We use a percentile ranking to reflect plant size rather than the very small, small, and large plant size categories used by FSIS because a percentile ranking gives a direct measure of output over five plant sizes for a particular type of output.

Table 1—Survey sample description

Plant type	Population	Respondents	Percent
Cattle slaughter	108	55	51
Hog slaughter	114	76	67
Cattle and hog slaughter	185	121	65
Chicken slaughter	181	91	50
Turkey slaughter	33	19	58
Chicken and turkey slaughter	21	12	57
Processing only	1,063	622	62
Total	1,705	996	58

Source: ERS.

[6]The survey was not designed to be a nationally representative sample of all plant types. In addition to excluding all nonmanufacturing plants, the sample includes only those plants that responded to the survey, making the sample inherently biased. There does appear to be a fair degree of balance in the responses in that the share of total output of plant respondents closely tracks the number of plants that participated.

Table 2—Animal inputs per plant by plant size for cattle and hog slaughter plants[1]

	Cattle slaughter Size percentile		Hog slaughter Size percentile	
Input type	0-19	80-99	0-19	80-99
	-------Number of animals slaughtered per year-----			
Animal inputs:				
Cattle	161	191,781	142	19,952
Hogs	387	0	542	1,848,234
Other animal inputs	36	0	203	25,319
Number of plants	28	30	37	47

[1]Animal inputs based only on plants reporting one or more animal input.

Source: ERS.

Table 3—Product output share by plant size for cattle and hog slaughter plants[1]

	Cattle slaughter Size percentile		Hog slaughter Size percentile	
Product type	0-19	80-99	0-19	80-99
	Percentage of output			
Raw meat products:				
Carcasses	22.0	26.3	14.6	29.5
Ground beef or pork	19.2	11.2	20.7	10.6
Trim or other boneless beef or pork	14.8	27.9	11.1	14.2
Subprimal and fabricated cuts.	10.2	15.2	11.6	17.7
Other raw meat products	8.0	9.3	6.4	5.7
Total raw meat products	74.2	89.9	64.4	77.7
Cooked or otherwise further processed products	25.8	10.1	35.6	22.3
Mean pounds of output (1,000s of pounds per year)	186	260,127	340	259,308
Number of plants	28	27	42	47

[1]Average output shares are based on all reporting plants. About 40 percent of all plants did not respond to question about cooked products. Similarly, 20 percent of all plants failed to respond to questions about raw product outputs.

Source: ERS.

Table 4—Animal inputs per plant and mean output by plant size for poultry slaughter plants[1]

	Mean output by plant size Size percentile	
Input type	0-19	80-99
	Birds per year (thousands)	
Animal inputs:		
Chickens	1,081	597,457
Turkeys	22	53,135
Other poultry	855	10,169
Mean pounds of output (1,000s of pounds per year).	8,459	236,146
Number of plants	20	25

[1]Animal inputs based only on plants reporting one or more animal input.

Source: ERS.

Table 5—Product output share by plant size for poultry slaughter plants[1]

Product type	Size percentile 0-19	Size percentile 80-99
	Percentage of output	
Raw poultry products:		
Cut-up poultry and parts	45.9	43.7
Raw chicken processed beyond cut-up, such as marinated or deboned	17.4	27.4
Other raw poultry products	33.1	13.6
Total raw products	96.4	84.7
Cooked or otherwise further processed products	3.6	15.3
Mean pounds of output (1,000s of pounds per year)	8,459	236,146
Number of plants	19	25

[1]Average output shares are based on all plants. About 40 percent of all plants did not respond to question about cooked products. Similarly, 20 percent of all plants failed to respond to questions about raw product outputs.

Source: ERS.

Table 6—Mean plant output and product output share by plant size for processors with no slaughter operations[1]

Product type	Cooked meat processors—no slaughter Size percentile 0-19	Cooked meat processors—no slaughter Size percentile 80-99	Raw meat processors—no slaughter Size percentile 0-19	Raw meat processors—no slaughter Size percentile 80-99
	Percentage of output			
Raw meat products:				
Carcasses[2]	0.6	1.8	1.6	5.2
Ground beef or pork	11.0	5.8	20.1	22.9
Trim or other boneless beef or pork	9.0	2.9	13.9	9.7
Subprimal and fabricated cuts	2.6	3.2	8.6	8.7
Other raw meat products	9.7	7.5	16.2	19.3
Total raw meat products	32.9	21.2	60.4	65.8
Cooked or otherwise further processed products:				
Bologna, frankfurters and other luncheon meats	15.2	19.7	9.6	6.0
Pepperoni and other fermented, aged, dry or semi-dry products	8.6	8.5	3.8	1.6
Cooked beef or pork such as roast beef or oven-cooked hams	6.9	15.7	6.0	8.9
Smoked products, such as bacon	8.6	15.3	5.4	6.5
Other cooked or further processed products	27.8	19.6	14.8	11.2
Total cooked meat products	67.1	78.8	39.6	34.2
Mean pounds of output (1,000s of pounds per year)	3,698	91,518	4,407	101,848
Number of plants	63	67	67	77

[1]Average output shares are based on all plants. About 40 percent of all plants did not respond to questions about cooked products. Similarly, 20 percent of all plants failed to respond to questions about raw product outputs.
[2]Producers that also sell products or serve as intermediaries for other processors may have animal carcasses that they sell or ship intact even though their plant may not slaughter animals.

Source: ERS.

By contrast, plant categories specified by FSIS are based on the number of employees. If plants produce a substantial amount of nonmeat products, then most employees would have tasks devoted to nonmeat production. Thus, the FSIS designation reflects overall plant size but not the size of the meat or poultry operation.

Processing practices for the largest cattle slaughter plants differed dramatically from those of their smaller competitors. Plants in the top quintile slaughtered, on average, 60 times more cattle per year than the average of plants in the 2nd through 4th quintiles and butchered no other animals. By contrast, cattle slaughter plants that were smaller than the first quintile, on average, slaughtered more hogs than cattle, with the smallest plants slaughtering less than one head of cattle per day. Types of outputs also differed. Trimmings—boneless meat as a byproduct of fabricating other meat products or meat trimmed from bones for the direct purpose of producing boneless meat, such as ground meat—made up a large share of output from large cattle slaughter plants, while a sizeable share of meat products from small plants were further-processed products.

The tables also show that the smallest hog slaughter plants processed only 2 hogs per day while the largest ones butchered almost 7,700 per day and, in contrast to cattle slaughter plants, handled animals other than their primary species (hogs). In terms of outputs, fabricated cuts constituted the largest share of output from the biggest hog slaughter plants while the smallest plants did more further-processing.

Due to confidentiality requirements, we combined chicken and turkey slaughter under the more general poultry slaughter category. The largest poultry plants slaughtered almost 600 times more chickens and 2,000 times more turkeys per year than the smallest plants (table 4). Nearly half of poultry slaughter plants' output was in the form of cut-up poultry parts and about a fourth was processed beyond cut-up parts (table 5). Except for the largest plants, poultry slaughter establishments sold less than 10 percent of their products as further-processed products. The bigger share of cooked products for the largest plants is likely due to proportionately more turkey slaughter plants, which typically produce more poultry hams and luncheon meats than do chicken slaughter plants (Ollinger et al., 2000).[7]

ERS survey data from 350 cooked-meat processing plants with no slaughter operations show that about three-fourths of their output came from cooked, smoked, fermented, dried and other further-processed products and the remainder from raw processed products (table 6). About two-thirds of the products from raw-meat processors without slaughter operations were raw meat products. Ground beef and pork was the main product group, accounting a fifth of output. Carcasses claimed a very small share of output for both types of processors.

[7] "Cooked products" refer to all products subjected to heat treatment.

Findings

In this section, we summarize and interpret results of the ERS survey in the context of our economic model. The questionnaire contains three categories of questions. One major category asked operators about their costs of complying with the PR/HACCP rule and included some subjective assessments of the benefits and costs of the regulation. Also included in this category are questions asking about food safety investments not required under PR/HACCP. More than half the questions in the questionnaire dealt with food safety technology and production practices. As described earlier, these questions deal with equipment, production practices, sanitation, testing, and dehiding. The third category of questions asks about plant characteristics, including questions about plant production volume, output and input mixes, and types of markets served by plants.

PR/HACCP Rule Costs

The expenditures required for compliance under PR/HACCP for five meat and poultry industries are shown in table 7. Costs in tables 7-10 are tabulated only for those plants responding to all cost questions. As shown, poultry plants incurred 2 times as much in variable costs and more than 50 percent more in fixed costs than the next highest cost industry. These high costs are partly due to a much larger average plant size. Raw meat processors with no slaughter operations had the lowest costs.

The data in table 7 are from the ERS questionnaire. Capital expenditures are the total of property, plant, and equipment required (Q11 of the survey) and

Table 7—The cost of compliance per plant with the PR/HACCP rule in various industries[1]

Expenditure type	Industry: Slaughter: Cattle	Slaughter: Hog	Slaughter: Poultry	Processing: Cooked meat	Processing: Raw meat
	Dollars (thousands)				
Capital expenditures:[2]					
Property, plant, and equipment expenditures required to comply with PR/HACCP	281.5	251.8	630.7	376.0	259.5
HACCP planning costs	6.8	7.4	8.7	8.5	7.3
Total long-term expenditures	288.3	259.2	639.4	384.5	266.8
Variable costs due to PR/HACCP:[3]					
Production worker wage	61.8	44.5	141.8	48.6	37.4
Quality control (QC) worker wages	36.8	42.6	101.6	47.5	38.1
Nonlabor variable costs	111.5	31.9	259.8	62.1	41.0
Total variable costs	210.1	119.0	503.2	158.2	116.5
Number of plants	135	104	58	198	143

[1]Mean values are based on the number of respondents who answered all questions.
[2]Capital expenditures are longrun costs, meaning that they are either one-time costs or costs that are incurred over a period longer than 1 year. Fixed costs are expenditures since the PR/HACCP rule was mandated in 1996 and are based on estimates derived from Q11, Q12, and Q13 and the methodology described above. Since we do not know precisely when these costs were incurred, they are not assigned a net present value.
[3]Variable costs are annual costs and are based on Q14 (nonlabor variable costs) and Q7 (labor costs). See www.ers.usda.gov/data/haccpsurvey for complete text of the questions.
Source: ERS.

planning labor (Q15B) required complying with the PR/HACCP rule. Planning labor was converted to costs by multiplying the average wage rate for meat or poultry slaughter or processing industries from Census Bureau publications, divided by a 270-day work-year times the number of total planning days required to develop HACCP and sanitation plans, as reported in Q15B. Production worker costs and quality control worker costs are based on question Q7A and Q7B, average Census wages, and a 270-day work-year. Nonlabor variable costs come from Q14.

We also projected our within-survey estimates of the costs of the PR/HACCP rule to the industry as a whole. We estimate that total meat and poultry slaughter and processing industry investment amounted to about $570 million in HACCP-required investments and $380 million in variable costs per year to maintain HACCP quality-control programs.

The estimates of total PR/HAACP fixed costs and PR/HACCP variable costs were made in the following way:

- For the slaughter industries, we obtained total investments by size class and industry by multiplying the total expenditures made by all of the survey respondents in a particular size class and industry times the inverse of the respondents' share of output from all plants in that group.
- For cooked and raw meat processors with no slaughter operations, we multiplied total investment expenditures within each size class and industry by the inverse of their share of cooked or raw processed products from all plants in that group.
- Industry estimates are, then, the sum of expenditures of the size classes.

Market Mechanisms' Effect on HACCP Implementation Costs

At least three types of plants are more exposed to a competitive demand for greater food safety investments: those that are subject to food safety requirements embedded in contracts; those that are exporters whose products are inspected by food safety authorities in importing countries; or those that have brand names, which require greater plant attentiveness to food safety process control. These plants would likely have made many of the investments required under PR/HACCP before it became mandatory and, thus, should have a lower cost of complying.

Plants that are subject to buyers' food safety requirements, export meat or poultry products, or sell products under their own brand names had modestly lower costs of compliance with the PR/HACCP rule (table 8).[8] Cattle and hog slaughter facilities and cooked meat processing plants (no slaughter operations) that were subject to the same market mechanisms generally had lower fixed costs, and poultry slaughter plants subject to market mechanisms had lower variable costs.

A very sharp difference in costs between plants subject to market mechanisms and those not subject to these forces would suggest that market mechanisms impose the same kinds of requirements as those mandated under the

[8]Fixed costs for red meat are based on survey questions Q11 and Q15B and variable costs are based on questions Q7 and Q14 for red meat. The questions are identical for poultry. Questions asking about plant output markets (e.g., exports) are Q42 (exports), Q43 (local or national distribution), Q44 (buyer requirements), and Q45 (branded products).

Table 8—Plants subject to selected market mechanisms have lower fixed costs necessary for compliance with PR/HACCP[1]

	Market mechanism					
	Buyer food safety requirements		Export market		Product sold under own brand	
Plant type	No	Yes	No	Yes	No	Yes
	Dollars per pound					
Cattle slaughter:						
Variable costs[2]	0.021	0.022	0.021	0.021	0.018	0.023
Fixed costs[3]	0.025	0.024	0.024	0.020	0.031	0.021
Number of plants	66	54	90	45	24	112
Hog slaughter:						
Variable costs	0.023	0.030	0.021	0.024	0.019	0.022
Fixed costs	0.012	0.007	0.029	0.019	0.040	0.025
Number of plants	55	32	71	33	12	91
Poultry slaughter:						
Variable costs	0.011	0.008	0.022	0.008	D	0.010
Fixed costs	0.006	0.008	0.009	0.007	D	0.008
Number of plants	18	33	9	47	3	53
Cooked meat processing/ no slaughter:						
Variable costs	0.016	0.019	0.016	0.014	D	0.032
Fixed costs	0.050	0.023	0.043	0.025	D	0.020
Number of plants	104	99	128	75	3	195
Raw meat processing/ no slaughter:						
Variable costs	0.012	0.015	0.017	0.007	D	0.018
Fixed costs	0.018	0.015	0.019	0.013	D	0.014
Number of plants	75	64	93	46	D	D

[1]Plants are in five meat and poultry slaughter and processing industries.
[2]Variable costs are annual costs and are based on Q14 (nonlabor variable costs) and Q7 (labor costs. See www.ers.usda.gov/data/haccpsurvey for complete text of the questions.
[3]Fixed costs are expenditures since the PR/HACCP rule was mandated in 1996 and are based on estimates derived from Q11, Q12, and Q13 and the methodology described in section 8.

Notes: Number of plants varies because all plants did not respond to all questions.
D: Disclosure violation, meaning information is suppressed.

Source: ERS.

PR/HACCP rule. The very modest difference actually observed, however, indicates one of two things: (1) either the requirements imposed by market mechanisms and those mandated under the PR/HACCP rule are very different, suggesting that both plants subject to market mechanisms and those not subject to these forces had a similar number of tasks to perform to be in regulatory compliance; or (2) plants subject to market mechanisms and those not subject to these forces had a similar number of tasks to perform in order to be in compliance with PR/HACCP because the regulation requires only tasks that most plants would perform regardless of whether they were subject to market forces (like plant A in figure 1).

We suspect that one question was poorly worded and may have elicited unintended responses from plants selling products under their own brand.

Our intent for the question asking plants whether they sell products under their own name was to see if the plant produced branded products for consumers. However, it appears that plants took it to mean whether their product was shipped to a buyer with the producer's name on the product, regardless of whether it was going to consumers or a vendor to be repackaged or further processed. Given this meaning, virtually all poultry plants and processors without slaughter operations answered affirmatively and even most cattle slaughter plants, which typically produce products that are sold under store brands in grocery stores, responded positively.

Plant Characteristics Affect Expenditures for Compliance with PR/HACCP

We considered three dimensions in which the PR/HACCP rule may have differential effects. First, we examined the PR/HACCP rule and plant size. Economists, such as Thomas (1990) and Ollinger and Fernandez-Cornejo (1998), among others, found that regulation adversely affects research productivity more in small firms than in larger ones in the pharmaceutical and pesticide industries. Pashigian (1984) found that environmental regulation of production facilities favored large factories over smaller ones and capital-intensive industries over more labor-intensive ones. These size and industry effects suggest that small plants may have higher regulatory costs per pound of meat or poultry than larger ones under PR/HACCP and that differential costs may exist between poultry and red meat plants.

Second, the costs of implementing the PR/HACCP rule also could vary by the degree of sophistication of a plant's quality control program prior to PR/HACCP. Since product testing, use of a plant schematic that identifies critical control points, and periodic reviews of the schematic and production process to ensure plant process control are essential components of HACCP, plants employing these practices prior to promulgation of the PR/HACCP rule may have had lower PR/HACCP compliance costs.

Third, there are also some indirect effects of regulation. On the one hand, product quality, i.e., shelf life for meat and poultry products, may rise because of better control over pathogens. On the other hand, plants imposing a higher quality standard may have to either slow production lines, shut down lines more frequently to make adjustments necessary to meet stricter standards, or discard more products.[9]

Plant Size and the Costs of PR/HACCP

The costs of PR/HACCP per pound of meat or poultry in slaughter and processing industries for the largest and smallest plants and the entire industry are shown in table 9. The weighted cost is much lower than the average cost per pound per plant because the very largest plants have minuscule costs per pound and those plants produce most of the output.[10] If plants were of generally equal size, then average cost per pound per plant would equal the weighted cost per pound.

The table shows that unweighted variable costs were three times higher for the smallest relative to the largest cattle slaughter plants, and fixed costs

[9]Plants can attain a higher level of product quality by either modifying production processes or discarding products that do not meet the standard. If they modify their production processes, then production costs rise. If they discard products that fail to meet the new standard, then the cost of product waste rises.

[10]The weighted average cost is weighted by plant output. We do this by summing costs within a percentile grouping and then summing output within the same grouping. Cost per pound is then the sum of costs divided by the sum of output. The unweighted cost is the mean of cost per pound of all plants.

were more than six times larger.[11] Estimates show that the average costs per pound per plant were around 1.5 to 2.5 cents per pound in variable and fixed costs for cattle and hog slaughter plants. The three right columns show that the weighted cost per pound is much lower than mean cost per pound per plant. For both hogs and cattle slaughter, the weighted cost per pound was less than one-half of a cent and about one- seventh the average cost per pound per plant.

The cattle and hog slaughter industries are comprised of a few very large plants that produce most of the output and numerous smaller plants that produce a blend of commodity and niche products. In cattle slaughter, plants in the 80th to 99th percentiles produce about 90 percent of all output and most of that quintile's output was produced by a few giant plants. The giant plants, in turn,

[11]The fixed costs are the costs of compliance with the PR/HACCP rule since its inception in 1996. We do not know precisely when plants made their investments, so these costs are not all in current dollars. Despite this inaccuracy, the magnitude of the differences suggests differences in costs. Larger plants had to comply with the PR/HACCP rule before the smallest plants; thus, their investments would have likely been made before the smaller plants, suggesting that their fixed costs may have actually been higher in current dollars than those of smaller plants.

Table 9—PR/HACCP costs of plants subject to market mechanisms[1]

	Unweighted mean cost per pound[2]			Industry weighted mean cost per pound[3]		
	Size percentile			Size percentile		
Plant type	0-19	80-99	Mean	0-19	80-99	Mean
	Dollars per pound					
Cattle slaughter:						
Variable costs	0.023	0.008	0.022	0.010	0.003	0.0033
Fixed costs	0.055	0.009	0.022	0.020	0.004	0.0045
Number of plants	17	27	135	17	27	135
Hog slaughter:						
Variable costs	0.016	0.005	0.014	0.008	0.001	0.0020
Fixed costs	0.050	0.008	0.026	0.022	0.003	0.0043
Number of plants	23	22	96	17	22	96
Poultry slaughter:						
Variable costs	0.025	0.004	0.010	0.023	0.004	0.0037
Fixed costs	0.013	0.004	0.008	0.012	0.003	0.0047
Number of plants	14	9	58	14	11	58
Cooked meat processing /no slaughter:[4]						
Variable costs	0.018	0.005	0.016	0.015	0.005	0.007
Fixed costs	0.079	0.019	0.036	0.057	0.015	0.018
Number of plants	50	37	198	50	37	198
Raw meat processing/no slaughter:[5]						
Variable costs	0.020	0.005	0.013	0.006	0.003	0.0046
Fixed costs	0.027	0.012	0.017	0.006	0.005	0.0080
Number of plants	25	26	139	25	26	139

[1]In the five meat and poultry slaughter and processing industries we left out intermediate percentiles from 20-79 because they follow a trend of higher to lower costs.
[2]Plants are in five meat and poultry slaughter and processing industries.
[3]Many plants answered only some of the questions. We used only plants reporting all variable and fixed costs. The average costs are the average costs for that percentile category only.
[4]The weighted average cost is weighted by plant output. We do this by summing costs and then summing output. Cost per pound is then the sum of costs divided by the sum of output. The unweighted cost is the mean of cost per pound of all plants.
[5]Estimated number of plants producing cooked or raw processed meat is based on either cooked or raw meat output as a share of total output, as indicated in the survey. For example, plants with more than 50 percent of their output coming from cooked products were defined as cooked meat processors.
Source: ERS.

have very low costs of compliance with PR/HACCP, making the weighted regulatory cost per pound much lower than the average cost per pound per plant. Poultry slaughter and the processing industries have similar effects.[12]

The substantial gap between the weighted cost per pound and average cost per pound per plant suggests heterogeneous price changes in the meat and poultry industries. The largest plants produce commodity products, like cut-up and boneless meat and poultry, and sell their products in mass markets. For these products, the largest plants drive prices and their costs, in turn, determine their prices. So, price increases would be imperceptible for commodity-like raw red-meat products. For smaller plants that produce commodity products that compete with commodity products from the giant plants, this means an erosion of profitability and a necessity to either exit the industry or shift to other products.[13]

Plants that produce unique products or produce products in small batches that compete against other small plants might be able to recover all of their PR/HACCP costs by raising prices. These plants would typically be the very smallest plants. Thus, it is the plants in the middle between the very small plants and the very largest plants that will feel the most cost pressures due to PR/HACCP. Effects should be similar for hog and poultry slaughter industries.

Meat Type and the Costs of PR/HACCP

The weighted cost of compliance with the PR/HACCP rule per pound of output in the poultry slaughter industry was about equal to that of cattle and twice as high as that for hog slaughter (see table 9, last column). Antle (2000) estimated cost of poultry production as about half that of beef. Combined, these imply that the percentage price increase in the cost of poultry products due to PR/HACCP is about twice that of beef.

One major difference between poultry plants and red meat plants is that poultry slaughter plants tend to be more vertically integrated into processing. Thus, it may be appropriate to compare the cattle and hog slaughter costs plus the red meat processing costs with the poultry slaughter costs. For raw products, costs due to PR/HACCP become about the same for beef and poultry, but remain lower for pork relative to poultry. Beef and pork costs plus either raw processing or cooked processing costs exceed those for poultry, suggesting that beef and pork costs may be greater than poultry in both percentage and absolute values. In either case, however, the average cost is less than 1 cent per pound.

Process Control Programs and Costs Prior to PR/HACCP

Now consider how having a more sophisticated process control program prior to PR/HACCP affected the cost of implementing the PR/HACCP rule. Process control programs prior to PR/HACCP were assumed to consist of systems that enable plant operators to identify critical control points, monitor performance at the critical control points, verify cleanliness through testing, and respond to deviations from standards. See questions Q17, Q18, and Q29 in the survey.

[12]Large-plant compliance costs with PR/HACCP may be somewhat lower than those of smaller plants because they would have been more likely to have had to comply with buyer requirements prior to PR/HACCP.

[13]Hooker et al. (1999) argue that small plants facing cost pressure in one market could shift to other products or simply stop production of their unprofitable product lines.

PR/HACCP costs of compliance for plants with process control programs prior to PR/HACCP were either lower or about the same as plants without these programs prior to PR/HACCP (table 10). Variable cost differences were quite small except for cattle and hog slaughter plants and small raw meat processing plants. Fixed costs of compliance were lower for large cattle slaughter plants and all small plants with process control programs prior to PR/HACCP. For other plants, fixed costs of compliance were comparable. These cost differences suggest that a process control program prior to PR/HACCP had many components similar to the requirements promulgated under the PR/HACCP rule and that these similarities gave plants with these programs lower costs of compliance with PR/HACCP.

Indirect Effects of the PR/HACCP Rule

Changes in food safety process controls have both positive and negative indirect impacts on production costs. Roberts and Pinner (1990), for example, found that better control of the pathogen *Listeria monocytogenes* led to an increase in product shelf life. The PR/HACCP rule appears to have had a similar effect. Survey results indicate that about 9 percent of respondents

Table 10—PR/HACCP costs for plants with pre-PR/HACCP process control program

	Plant size[1]			
	Small		Large	
	Process control prior to PR/HACCP		Process control prior to PR/HACCP	
Plant type	No	Yes	No	Yes
	Dollars per pound		*Dollars per pound*	
Cattle slaughter:				
Variable costs	0.036	0.020	0.016	0.008
Fixed costs	0.039	0.025	0.016	0.006
Number of plants	47	10	57	21
Hog slaughter:				
Variable costs	0.035	D	0.019	0.008
Fixed costs	0.059	D	0.017	0.016
Number of plants	D	D	60	12
Poultry slaughter:				
Variable costs	0.016	D	0.005	0.004
Fixed costs	0.011	D	0.002	0.005
Number of plants	D	D	16	11
Cooked meat processing /no slaughter:				
Variable costs	0.020	0.020	0.012	0.009
Fixed costs	0.058	0.020	0.024	0.022
Number of plants	78	24	62	34
Raw meat processing/no slaughter:				
Variable costs	0.019	0.011	0.011	0.008
Fixed costs	0.019	0.006	0.017	0.017
Number of plants	55	14	52	22

[1]Large plant size is defined as any plant in the 50th or higher percentile in all industries, except for hogs, in which the cutoff for large plants was the 70th or higher percentile. The cutoff was changed in order to avoid potential confidentiality concerns.
D: suppressed due to confidentiality concerns
Source: ERS.

stated that their products' shelf lives increased by more than 1 week and 21 percent said that their products' shelf lives increased by less than 1 week. Only about 1 percent of respondents claimed a decrease in shelf life. The remainder reported no change in shelf life.

Implementing a new process control program or making an existing program more stringent can have two indirect effects on production costs:

- On the one hand, products may better satisfy buyers and result in a reduction in product recalls, an improvement in product yields, and a decline in plant downtime if the plant formerly had a poorly functioning process control program.
- On the other hand, a more stringent process control program may reject products that formerly would have been sold to buyers and may cause a plant to shut down more frequently in order to comply with new process control requirements.

A case study of Texas American Beef (Golan et al., 2004) indicates that Texas American Beef instituted a process control program to reduce product recalls and then successfully implemented a program that led to a competitive advantage in pathogen control technology. Thus, this privately motivated process control program generated substantial benefits to its developer.[14] Government mandated process controls, however, differ in that no plant gains a competitive edge over its rivals because all plants must comply with the same standard. Plants can gain an advantage only if they perform at a level greater than the industry mean.[15] Thus, companies like Texas American Beef may have a quality level comparable to that of Plant D in figure 1 while the rest of the industry would reside at the horizontal bar. If the regulatory standard becomes more stringent, then companies, such as Texas American Beef, would have to increase their food safety process control standards even further to distinguish themselves from their competitors.

The PR/HACCP rule raised regulatory stringency by raising the acceptable level of food safety and the stringency of process control requirements.[16] Plants could deal with the regulation by either removing meat that failed to meet FSIS standards as it occurred in production or increasing work effort and processing complexity to prevent the production of the off-quality meat or poultry from happening in the first place.[17] If a plant removed meat or poultry that failed to meet FSIS standards from production as it occurred, then processing yields may have declined because product that would have otherwise been sold must now be rejected. ERS survey data suggest that many plants followed this route. Only about 2 percent of the 963 plants reporting on plant yields believed that yield improved with the introduction of the PR/HACCP rule, while about 25 percent believed that yield decreased. The remainder reported no change. See question Q10 in the survey to review the survey question.

Some plants that increased processing complexity by adding a new step, such as a steam vacuum cleaner to remove fecal matter, to the production process to meet more stringent pathogen-control standards would incur the cost of greater downtime because those plants would have to shut down when the new step in the production process failed. However, if a plant that had been experiencing

[14]This is not to say that production costs actually dropped. Product recalls may have declined because products that would have formerly been released for sale were held and then either sold for alternative uses or discarded. Texas American Beef did reduce some of this rejected meat as it further developed its process control program but a detailed study of its costs is not available. It is clear, however, that improving its process control program gave Texas American Beef a competitive advantage at a time when buyers were becoming more discriminating in their purchasing behavior and enabled it to increase market share at the expense of its competitors.

[15]For example, automobiles produced by American companies have improved in quality over the past 30 years; yet many Japanese automobiles sell at a premium because they have even higher quality. The important point is that relative quality matters.

[16]Regulatory stringency increased in two ways. First, in production, slaughter plants now have to conduct a test for *E. coli* and comply with a generic *E. coli* standard, and slaughter and ground meat plants must adhere to a *Salmonella* standard. Neither type of testing was required prior to PR/HACCP. Additionally, plants must keep records on and adhere to their SSOP and HACCP practices. Second, in the marketplace, FSIS increased the number and sensitivity of tests for harmful pathogens. This increased diligence has led to a sharp spike in product recalls. See "Weighing Incentives for Food Safety in Meat and Poultry" in the April 2003 issue of *Amber Waves* for further discussion about the nature of the recalls.

[17]The PR/HACCP rule specifies two process standards—SSOPs and HACCP plan implementation—that require plants to perform specified functions. There are also two performance standards—*E. coli* and *Salmonella* testing that indicate a failure in the food safety system. Plants could avoid such failures by either improving their food safety system or testing animals and meat for *E. coli* and *Salmonella* and discarding those that are not acceptable. Either approach can achieve a safe food supply. The last option—test and discard—is very costly, however.

frequent shutdowns due to poor processing practices introduced an improved process control program, then production downtime may have been reduced. ERS survey data (Q9 in the survey) suggest that many more plants realized an increase than a decrease in production downtime.

Now consider the four components of the PR/HACCP rule—compliance with the HACCP plan, SSOPs, the zero fecal matter/generic *E. coli* standard, and the *Salmonella* standard—and changes in annual downtime. About 12 percent of all plants said they had more than 24 hours of annual downtime due to HACCP compliance and 46 percent said they had between 0 and 24 hours of additional downtime. Only 4 percent indicated a reduction in production downtime. Plants gave a similar report for SSOPs, but had a more positive experience with the zero fecal matter standard and *Salmonella* testing. For the fecal matter standard, 18 percent of all plants said the requirement reduced downtime while only 7 percent said that downtime rose by more than 24 hours; 29 percent indicated a rise in downtime of less than 24 hours. Similarly, 15 percent of all plants said the *Salmonella* standard reduced downtime while only 2 percent said that downtime rose more than 24 hours; 20 percent indicated a rise in downtime of less than 24 hours. Overall, 54 percent of all plants said that they suffered downtime due to one of the four components of PR/HACCP with no offsetting downtime reductions in another component. Only 6 percent of all plants said that downtime declined in at least one of the components and did not change in the others. About 13 percent of all plants realized reductions in downtime due to one component but then had offsetting increases in downtime due to other components. The remainder of the plants had no changes in downtime due to PR/HACCP.

Food Safety Investment

Total fixed capital investment in food safety includes the expenditures required for compliance with regulation and the private investment motivated by market conditions. The cost of government regulation includes costs that firms otherwise may not incur. Privately motivated investments, on the other hand, are those expenditures that plants are not required to make in order to comply with regulation and for which the discounted net return to the firm is greater than or equal to the cost of the initial amortized expenditure. This independent private investment includes the cost of installation, the price of the equipment, lost downtime during installation, and transportation costs. Improvements in firm profitability come from cost savings due to reductions in labor costs and material usage, a longer shelf life, and higher prices accruing to a higher quality product. For food safety, a reduction in business risk is an important motivating factor. New technologies and more frequent use of existing practices increase the likelihood of adhering to FSIS standards and make it less likely that a plant will be either subject to a product recall or identified as the source of a foodborne illness.

Table 11 shows the estimated mean level of independent private investments and capital expenditures required for compliance under PR/HACCP for five meat and poultry industries. For the 136 cattle slaughter plants responding to all investment questions, the mean level of independent private investment was about $181,500 per plant and total capital expenditures and HACCP planning costs required for compliance with PR/HACCP

Table 11—Mean privately motivated capital expenditures and capital expenditures required for compliance with PR/HACCP[1]

Expenditure type	Industry				
	Slaughter			Processing	
	Cattle	Hog	Poultry	Cooked meat	Raw meat
	Dollars per plant (thousands)				
Capital expenditures:					
Expenditures required to comply with PR/HACCP	281.5	251.8	630.7	376.0	259.5
Privately motivated investment, not needed to comply with PR/HACCP	181.5	227.6	501.7	298.2	130.9
HACCP planning costs	6.8	7.4	8.7	8.5	7.3
Total long-term expenditures	469.8	486.8	1141.1	682.7	397.9
Number of plants	136	104	56	203	143

Note: Mean values are based on the number of respondents who answered all questions.
[1]In the meat and poultry slaughter and processing industries.

Source: ERS.

amounted to about $288,000. Of the five industries, poultry slaughter had the highest level of private investment ($500,000 per plant) while raw meat processing had the lowest level of private investment at about $130,900 per plant. See Q11 in the survey for the precise wording of the question soliciting information.

Private plant investment estimates are based on the expenditures required to comply with the PR/HACCP rule. We assumed that plants made private investments only if their survey response indicated that they made food safety process control investments beyond those mandated under PR/HACCP (Q12 in the survey). If plants did and they responded affirmatively to another question asking whether their private investment exceeded their PR/HACCP-required investment (Q13 in the survey), we make a lower bound estimate by assuming that private investment equaled PR/HACCP expenditures. For plants indicating that they made investments in addition to those mandated under PR/HACCP but also responding that this investment did not exceed their PR/HACCP costs, we assumed that private investment was one-half the PR/HACCP investment. Finally, we assumed that private investment equaled zero if the plant indicated that it made only PR/HACCP-required investments. Total respondent investment per industry, the sum of investments across all respondents, was then adjusted as outlined in section 6 to obtain private industry investment. We acknowledge that these are rough, but we believe that they do provide a general feel for the amount of investment put forth by meat and poultry slaughter and processing plants.

The Paths Plants Took To Comply With the PR/HACCP Rule

The components of the PR/HACCP rule that deliver the most benefits in terms of food safety process control are of major importance to policymakers. To meat and poultry processors, the lowest cost way to comply with PR/HACCP is of primary importance. Economists, on the other hand, believe that additional process control should be added up to the point at which the cost of process control equals the benefits of improved public health. This balance of process control costs and public health outcomes may or may not be equal to the level of food safety process control achieved through compliance with PR/HACCP regulation.

Two types of regulatory standards—performance and process standards—exist to achieve regulatory goals. Performance standards allow plants to use any means necessary to reach an established goal that is linked to a public good, such as improved health. Process standards mandate specific processes that manufacturers must achieve in order to comply with the regulation. HACCP contains elements of both: generic *E. coli* and *Salmonella* performance standards and SSOP and HACCP process standards.

Economists generally believe that process standards are more costly than performance standards because some required tasks may not be necessary to reach desirable outcomes. However, process standards do reduce the uncertainty of regulatory compliance because as long as the plant executes the necessary tasks it is in compliance, whereas performance standards require a plant to first investigate a quality breakdown and then develop a solution. Determining the solution and then implementing ways to carry it out can be both costly and time-consuming and require repeated approaches to problem solving. We consider the aspects of the PR/HACCP rule that plants felt were most beneficial and most costly, as follows.

Questions 1-3 of the survey asked plant operators how they perceived the costs and benefits of the PR/HACCP rule. Tables 12a-13b indicate the perceived benefits and costs associated with aspects of the PR/HACCP rule. First, consider the SSOPs and HACCP plans. The tables show that managers in all industries except poultry slaughter believed that SSOPs delivered the most benefits for pathogen control, yet far fewer plants said it was the most costly component of the PR/HACCP rule. A substantial number of plants also thought that HACCP plans were the most important component for pathogen control, but a much larger number claimed it was the most costly way to achieve it. Small plants incurred sharply higher relative costs of creating and implementing HACCP plans. Nearly twice as many of the smallest slaughter plants relative to the largest ones believed that compliance with HACCP plans was the most costly aspect of the PR/HACCP rule.

Operator frustration over the costliness of HACCP plan development implementation account for the overwhelming majority of written comments on the HACCP plan. One operator was particularly expressive, saying:

"Our plant is small (18 employees) but has a very complex product mix, from fresh beef and pork cuts all the way to finished, ready-to-eat products.

Table 12a—Slaughter plants' rating of part of PR/HACCP rule considered most beneficial for pathogen control[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
	Share of plants saying component most beneficial		
Cattle slaughter:			
SSOPs	41.0	32.0	36.0
HACCP plan	16.0	25.0	23.0
E. coli testing, zero fecal requirement	37.0	36.0	36.0
Salmonella testing	0.0	0.0	1.0
Other	6.0	7.0	4.0
Number of plants	48	49	255
Hog slaughter:			
SSOPs	36.0	49.0	40.0
HACCP plan	25.0	16.0	23.0
E. coli testing/zero fecal requirement	32.0	26.0	30.0
Salmonella testing	0.0	9.0	3.0
Other	7.0	0.0	4.0
Number of plants	42	47	210
Poultry slaughter:			
SSOPs	37.0	21.0	24.0
HACCP plan	33.0	37.0	29.0
E. coli testing/zero fecal requirement	26.0	32.0	28.0
Salmonella testing	4.0	5.0	16.0
Other	0.0	5.0	3.0
Number of plants	33	24	124

[1]Responses are based on Q2 in the survey. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.

Source: ERS.

Table 12b—Processing plants' rating of part of PR/HACCP rule considered most beneficial for pathogen control[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
	Share of plants saying component most beneficial		
Cooked meat processing, no slaughter:			
SSOPs	44.0	49.0	45.0
HACCP plan	36.0	35.0	37.0
E. coli testing/zero fecal requirement	14.0	11.0	13.0
Salmonella testing	4.0	0.0	1.0
Other	2.0	5.0	4.0
Number of plants	68	73	368
Raw meat processing, no slaughter:			
SSOPs	48.0	45.0	44.0
HACCP plan	36.0	34.0	36.0
E. coli testing/zero fecal requirement	12.0	17.0	14.0
Salmonella testing	2.0	2.0	2.0
Other	2.0	2.0	4.0
Number of plants[2]	65	58	327

[1]Responses are based on Q2 in the survey. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.
[2]Two raw meat processing plants have missing rank data.

Source: ERS.

Table 13a—Slaughter plants' rating of parts of PR/HACCP rule considered most costly[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
	Share of plants saying PR/HACCP component most costly		
Cattle slaughter:			
SSOPs	7.0	2.0	6.0
HACCP plan	48.0	37.0	43.0
E. coli testing/zero fecal requirement	41.0	49.0	43.0
Salmonella testing	4.0	4.0	4.0
Other	0.0	8.0	4.0
Number of plants	48	49	255
Hog slaughter:			
SSOPs	12.0	15.0	11.0
HACCP plan	53.0	28.0	45.0
E. coli testing/zero fecal requirement	30.0	31.0	34.0
Salmonella testing	5.0	26.0	8.0
Other	0.0	0.0	2.0
Number of plants	42	47	210
Poultry slaughter:			
SSOPs	9.0	4.0	5.0
HACCP plan	41.0	21.0	26.0
E. coli testing/zero fecal requirement	34.0	63.0	50.0
Salmonella testing	16.0	8.0	16.0
Other	0.0	4.0	3.0
Number of plants[2]	33	24	124

[1]Responses are based on Q3 in the survey. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.
[2]Twenty-four poultry plants have missing rank data.
Source: ERS.

Table 13b—Processing plant rating of components of the PR/HACCP rule that is most costly varies by plant size[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
	Share of plants saying PR/HACCP component most costly		
Cooked meat processing, no slaughter:			
SSOPs	12.0	17.0	14.0
HACCP plan	55.0	47.0	58.0
E. coli testing/zero fecal requirement	16.0	28.0	18.0
Salmonella testing	9.0	4.0	4.0
Other	8.0	4.0	6.0
Number of plants	68	73	368
Raw meat processing, no slaughter:			
SSOPs	10.0	11.0	10.0
HACCP plan	62.0	51.0	59.0
E. coli testing/zero fecal requirement	13.0	28.0	21.0
Salmonella testing	8.0	7.0	6.0
Other	7.0	3.0	4.0
Number of plants[2]	65	58	327

[1]Responses are based on Q3 in the survey. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.
[2]Two raw meat processing plants have missing rank data.
Source: ERS.

To cover our many types of products, we had to develop and implement 19 separate HACCP plans, plus the SSOP procedures. Needless to say, this took a huge amount of time and resources. Our HACCP team of 9 individuals (half the plant [employees]) met for 1 to 2 hours on a weekly, sometimes biweekly, basis for 14 months. Additionally, one person worked half-time for two and a half years. Our direct labor cost for HACCP and SSOP plan development was well over $100,000. During this process, there were several false starts, as the 'rule' seemed to be constantly changing, a moving target if you will. Our plant has four certified people. Each of us attended separate HACCP certification training courses (3-day sessions required by law) and each of us brought back new or different requirements."

Now consider the perceived costs and benefits of *E. coli* testing and the zero fecal matter standard. As shown in the tables, a similar number of meat plant respondents regarded these two as most beneficial and most costly. However, the attitudes of managers of poultry plants differed sharply: half the plant managers viewed *E. coli* testing and the zero fecal standard as most costly while about only one-fourth of plant managers viewed it as most beneficial. This sentiment was most pronounced for the managers of large plants. More than 60 percent of these plant managers thought the *E. coli* testing and the zero fecal matter standard was most costly while only about 30 percent believed that it was most beneficial.

The Paths Plants Would Prefer To Take To Best Control Pathogens

It is one matter to ask a plant about compliance and another to ask plants the practices they might use to best control pathogens independent of any regulation. Ideally, the two would match. Questions 4, 5, and 6 ask plant operators about their preferred approach to control pathogens and the costliness of that method.

Tables 14a and 14b demonstrate clearly that plant size and, to a lesser degree, animal species and type of product have strong influences on how plants choose to control pathogens. Table 14a shows that the smallest cattle and hog slaughter plants prefer to concentrate on changes in product flow while their larger, more capital-intensive competitors and most poultry plants focused much more on equipment.[18] A large number of plants in all categories except large poultry plants viewed frequency of cleaning as the best way to control pathogens.

Table 14b shows that product flow and frequency of cleaning are important to processing plants of all sizes, whereas equipment was viewed as much less useful for pathogen control than it was in slaughter plants. It is also important to note that proportionately more raw meat processors regarded relationships with suppliers as the best way to control pathogens, probably because the PR/HACCP rule places responsibility for compliance with the *Salmonella* standard with grinders. Yet, plants that grind meat and poultry must rely on their suppliers to provide pathogen-free meat and poultry because, unlike slaughter plants, they have no means of reducing pathogens in meat supplies after their products are contaminated.

[18]Changes in product flow are adjustments to the production flow to enhance food safety. For example, a travel route for a bin of raw/unprocessed meat may be redirected from one route passing through a finished product area to another route that avoids this area, thereby reducing the potential for cross-contamination.

Table 14a—Slaughter plants' rating of food safety operation considered most beneficial for pathogen control[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
	Share of plants saying plant operation most effective		
Cattle slaughter:			
Grower practices	11.0	0.0	11.0
Product flow	30.0	7.0	24.0
Product rework	3.0	3.0	3.0
Frequency of cleaning	32.0	26.0	26.0
New equipment	14.0	45.0	22.0
Facilities improvement	5.0	17.0	12.0
Other	5.0	2.0	2.0
Number of plants	48	49	255
Hog slaughter:			
Grower practices	22.0	7.0	12.0
Product flow	28.0	12.0	29.0
Product rework	0.0	5.0	3.0
Frequency of cleaning	28.0	21.0	19.0
New equipment	10.0	43.0	23.0
Facilities improvement	6.0	12.0	11.0
Other	6.0	0.0	3.0
Number of plants	42	47	210
Poultry slaughter:			
Grower practices	0.0	23.0	10.0
Product flow	18.0	9.0	12.0
Product rework	4.0	5.0	2.0
Frequency of cleaning	25.0	9.0	12.0
New equipment	39.0	41.0	51.0
Facilities improvement	7.0	14.0	9.0
Other	7.0	0.0	4.0
Number of plants	33	24	124

[1]Responses are based on Q4 in the survey. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.

Source: ERS.

Taken together, tables 14a and 14b indicate an interaction between the tools required to control pathogens and plant production technology and product mix. Large, high-speed slaughter facilities must process animals quickly in order to be profitable and so rely on high-speed equipment as much as possible to control pathogens. Small, more labor-intensive slaughter operations, by contrast, can control pathogens by ensuring a smooth product flow and intensive cleaning. Intermediate sized plants may use some equipment to control pathogens, but must still rely substantially on manual means of control. Large poultry slaughter plants, perhaps the most automated of all plants, rely almost exclusively on equipment to best control pathogens. Processing plants, in contrast, have few mechanical means of controlling pathogens; thus, they must rely on cleaning and product flows, and, for raw-meat processors, assurance from suppliers that their inputs are pathogen-free.

Tables 15a and 15b indicate plant operators' perceptions of the costliness of various operational changes. Except for small plants in two categories, managers regarded equipment as the most costly way to control pathogens while

Table 14b—Processing plants' rating of food safety operation considered most beneficial for pathogen control[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
	Share of plants saying plant operation most effective		
Cooked meat processing, no slaughter:			
Grower practices	4.0	9.0	11.0
Product flow	27.0	17.0	22.0
Product rework	2.0	6.0	4.0
Frequency of cleaning	39.0	28.0	29.0
New equipment	16.0	16.0	15.0
Facilities improvement	12.0	22.0	16.0
Other	0.0	2.0	3.0
Number of plants	68	73	368
Raw meat processing, no slaughter:			
Grower practices	17.0	21.0	15.0
Product flow	27.0	11.0	23.0
Product rework	2.0	13.0	6.0
Frequency of cleaning	29.0	17.0	26.0
New equipment	15.0	17.0	14.0
Facilities improvement	10.0	17.0	14.0
Other	0.0	4.0	2.0
Number of plants[2]	65	58	327

[1]Responses are based on Q4 in the survey. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.
[2]Two plants have missing rank data.

only the managers of large plants believed that equipment is most useful for pathogen control. Small plants claimed that the frequency of cleaning is effective and less costly than equipment, but still costly. A substantial number of plant managers also viewed product flow as useful, but a much lower number regarded it as most costly. A sizeable number also regarded facilities improvement as quite costly. Overall, large plants appeared to favor equipment-based process control approaches, while smaller plants preferred either the frequency of cleaning or product flow process control programs.

Construction of a Food Safety Technology Index

The ERS survey contained approximately 35 questions dealing with food safety technology and practices covering five broad categories: food safety equipment, testing, plant operations, sanitation, and dehiding (cattle slaughter only). These questions queried plant managers about how their plants controlled pathogens. Examples of each type of question include the use of equipment to heat carcasses, amount of pathogen testing, quantity of worker training, frequency of sanitation practices, and use of negative air pressure around the carcass in the dehiding area. We have included all of the questions and frequency of responses in the survey. In the meat questionnaire, questions Q19-Q40 and Q52-Q65 deal with food safety technologies. The poultry food safety technology questions are Q20-Q41 and Q53-Q65.

A practice adhered to by quality control managers in meat and poultry plants is to consider food safety technology as a system in which a plant

Table 15a—Slaughter plant rating of food safety operation that is most costly[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
	Share of plants saying plant operation most costly		
Cattle slaughter:			
Grower practices	0.0	0.0	3.0
Product flow	5.0	9.0	11.0
Product rework	5.0	2.0	4.0
Frequency of cleaning	29.0	13.0	16.0
New equipment	37.0	42.0	35.0
Facilities' improvement	22.0	29.0	27.0
Other	2.0	5.0	4.0
Number of plants	48	49	255
Hog slaughter:			
Grower practices	0.0	2.0	3.0
Product flow	5.0	0.0	11.0
Product rework	3.0	4.0	4.0
Frequency of cleaning	20.0	7.0	12.0
New equipment	36.0	55.0	39.0
Facilities' improvement	28.0	30.0	27.0
Other	3.0	2.0	4.0
Number of plants	42	47	210
Poultry slaughter:			
Grower practices	0.0	4.0	3.0
Product flow	13.0	4.0	6.0
Product rework	13.0	4.0	8.0
Frequency of cleaning	17.0	13.0	11.0
New equipment	43.0	58.0	58.0
Facilities' improvement	10.0	13.0	10.0
Other	4.0	4.0	4.0
Number of plants	33	24	124

[1]Responses are based on Q5 in the survey. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.

Source: ERS.

marshals several different types of equipment or practices to control food safety.[19] In this vein, we consider the overall system of food safety. However, it is more precise to compare similar technologies and production practices, e.g., equipment of one plant to equipment of another rather than a mixture of technologies and practices, such as equipment and sanitation because plants may use similar equipment but have different sanitation, making the two plants appear to have much different technologies than actually occurs. As a result, we created five food safety technology indexes—food safety plant operations, testing, sanitation, equipment, and dehiding (cattle slaughter)—that correspond with the five different types of food safety technology questions in the survey.

We adhered to three principles in creating the food safety technology index. First, the rating system should be monotonic because more intensive operations should yield greater food safety protection than less intensive ones. By monotonic, we mean that plants with more intensive cleaning or with a specific piece of food safety equipment have higher scores than plants with less

[19]A multiple-hurdle system in a high-volume cattle slaughter plant may involve a battery of steam vacuum units, a carcass pasteurizer, organic sprays, and other related equipment. Each type of equipment reduces pathogen levels but none completely eliminates them.

Table 15b—Plant operation processing plants believe is most effective way to control pathogens[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
	Share of plants saying plant operation most costly		
Cooked meat processing, no slaughter:			
Grower practices	7.0	3.0	4.0
Product flow	7.0	13.0	9.0
Product rework	6.0	7.0	11.0
Frequency of cleaning	28.0	12.0	19.0
New equipment	19.0	32.0	25.0
Facilities' improvement	28.0	32.0	29.0
Other	5.0	1.0	3.0
Number of plants	68	73	368
Raw meat processing, no slaughter:			
Grower practices	13.0	9.0	7.0
Product flow	7.0	9.0	8.0
Product rework	7.0	11.0	7.0
Frequency of cleaning	27.0	7.0	20.0
New equipment	20.0	35.0	28.0
Facilities improvement	20.0	25.0	26.0
Other	6.0	4.0	3.0
Number of plants[2]	65	58	327

[1]In terms of share of plants by plant size. Responses are based on Q5 in the survey. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.
[2]Two plants have missing rank data.
Source: ERS.

intensive cleaning or without the same piece of equipment. Second, one should be able to make food safety technology comparisons on the basis of similar technology types since some types of technology, such as plant operations, may have different purposes and long- and short-term effects than other technologies, such as equipment. Thus, the relevant comparisons are the equipment rating of one plant versus that of another and sanitation of one plant versus that of another, etc.

Third, since food safety quality control requires a systematic approach, we considered a variety of technology components within each technology type. For example, steam vacuum units, carcass pasteurizers, and other food safety equipment are equipment technologies. More precisely, we used questions Q21, Q24, Q25, Q30-Q35, and Q51 to construct a plant's operations technology index, Q26-Q28 for the testing technology index, Q36-Q40 for sanitation for the sanitation technology index, Q19, Q20, Q22, Q23, Q52-56 for the equipment technology index, and Q51 and Q58-Q65 for the dehiding technology index.[20] For poultry slaughter, the questions for each category are Q22, Q25, Q26, Q31-Q36, Q53, and Q54 for the plant operations index, Q27-Q29 for the testing index, Q37-Q41 for the sanitation index, and Q20, Q21, Q23, Q24, and Q55-62 for the equipment technology index.

Following the three underlying principles, the indexes were constructed as follows. First, we grouped similar technologies and practices into one of the five types of food safety practices and technologies described above, such as

[20]Dehiding refers to all the manufacturing operations, equipment, facilities, and sanitation practices associated with hide removal. It is a very important operation because, if done correctly, animal carcasses will not be exposed to harmful pathogens even if they are present in the animal's feces or on its hide.

testing. Second, we valued all questions equally with a maximum value of "1" and a minimum value of "0." Third, we assigned the most intensive operation within each question a value of 1 and the least intensive a value of 0. For example, equipment usage questions and similar questions had just two possible responses: 1 or 0. Many sanitation and plant operations questions, however, had multiple answers. For these questions, we assigned a 1 to the operation that generates the most food safety, a 0 to the operation generating the least food safety, and an intermediate value between 0 and 1 for operations providing intermediate food safety performance. Finally, we created a technology index for each technology category by summing the values of the responses for each of the questions within that category—plant equipment, testing procedures, plant operations, sanitation, and dehiding—and dividing by the number of questions, yielding an index value between 0 and 1. For the overall technology category, we divided the total of all technology questions by the total number of food safety technology questions.

Consider the following example. Suppose that a sanitation question asks whether a plant cleans its processing line once per week, less than daily but more than weekly, or daily. Using our approach, the plant would be assigned 0 points for weekly cleaning, 0.5 point for less than daily but more than weekly cleaning, and 1 point for daily cleaning. Suppose also that there are five questions under the sanitation category. The maximum number of points a plant could achieve would be 5 and the minimum would be 0. Since the index value equals the number of points (5 or fewer) divided by the number of questions (5) the index value ranges from 0 to 1.

There are many other ways to create food safety indexes. For our index, we assumed that all pathogen-control activities within a category were of equal importance. For example, sanitizing knives is of equal importance to washing hands. However, it may be that sanitizing knives is more important than washing hands, in which case knife sanitation should have a heavier weight than handwashing in the sanitation index. Alternatively, we assumed a linear scale between the least and most stringent measure within a question. For example, if there were three possible responses for product cooling, the end points garnered 0 or 1 point while the intermediate response generated 0.5 point. Yet, a log or other scale could have also been used and would have, likewise, been monotonic. Finally, the five categories may not be of equal importance. For example, it may be that sanitation and cleaning is more important than equipment. To partially accommodate this concern, we emphasize the categorical, e.g., index of pathogen-control equipment, rather than the overall pathogen-control plant rating in our discussion.

Large Plants Have Much Higher Equipment and Pathogen-testing Technology Index Values

Table 16a compares the food safety technology index of the largest plants with the smallest plants in three slaughter industries. The table shows that the smallest plants had much lower technology index values overall. Most of the difference is due to a substantial variation in equipment and testing for all three industries and dehiding for cattle slaughter. Sanitation and operating procedures were nearly the same. The greatest difference in sanitation is

Table 16a—Technology index for slaughter plants for five types of food safety technologies[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
		Technology index	
Cattle slaughter:			
Overall tech/methods	0.43	0.62	0.50
Equipment	0.32	0.55	0.39
Testing	0.34	0.75	0.51
Dehiding	0.26	0.45	0.36
Sanitation	0.51	0.59	0.56
Operations	0.59	0.70	0.62
Number of plants	48	49	255
Hog slaughter:			
Overall tech/methods	0.42	0.57	0.49
Equipment	0.35	0.46	0.38
Testing	0.27	0.70	0.49
Sanitation	0.50	0.55	0.55
Operations	0.58	0.62	0.60
Number of plants	42	47	210
Poultry slaughter:			
Overall tech/methods	0.50	0.67	0.61
Equipment	0.48	0.74	0.65
Testing	0.38	0.75	0.65
Sanitation	0.54	0.55	0.55
Operations	0.59	0.63	0.61
Number of plants[2]	26	27	148

[1]Index values derived from Q19-65 in the meat survey and Q20-62 in the poultry survey. See the text for how the index was determined. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.
[2]Twenty-four poultry plants have missing rank data.

Source: ERS.

the eight points separating the smallest and largest cattle slaughter plants. The operations' difference ranged from 4 to 11 points.

The differences in index values between small plants and large ones make sense. In cattle slaughter, equipment that raises carcass temperature to 160 degrees Fahrenheit or more to control pathogens can cost more than $1 million. Yet, the smallest cattle slaughter plants butchered an average of less than one cattle per day (table 2), and even plants in the second largest size grouping (80th percentile), slaughtered only about 60 cattle per day. By contrast, plants in the largest size category processed more than 100 cattle per hour. If we assume that equipment has a useful life of 5 years, then the cost is more than $1,200 per head of cattle for the smallest plant and about $1 per head for the largest plant. Of course, some equipment is cost-effective for small plants and they do adopt these technologies. If they did not, their ratings would be 0. Nonetheless, their equipment index value is naturally going to be a lot lower than that of large plants.

The costs of product testing are also higher for smaller plants because large plants have sufficient needs to create in-house quality control operations that can perform microbiological testing at a lower cost than that which is available on the market and to small plants.

It may be that large plants have to test much more frequently than smaller plants. Large plants are exposed to much greater risk of being found responsible for a foodborne illness outbreak. For example, a plant slaughtering 100 head of cattle per hour on 2 shifts would produce about 960,000 pounds of beef per day while the smaller plant would produce only 600 pounds, suggesting that the larger plant has a much, much greater chance of being subject to a product recall.

Sanitation and operating procedures can be more easily adjusted to accommodate plant size than can equipment because they are proportional to volume. For example, a superior sanitation practice, such as cleaning and sanitizing a cutting utensil after each carcass or cut of meat, has similar costs per cut of meat regardless of plant size. Nonetheless, these procedures still tend to favor large plants. Cleaning drains, for example, is a fixed cost over a period of time, so it has a cost that is more easily spread across many units, i.e., by large plants.

The dehiding process represents an intermediate case in which some costs are fixed, such as maintaining negative air pressure in the dehiding area, and other costs, such as cleaning knives and hands after each carcass, are more variable. Thus, food safety process control index values for small plants are lower than for larger plants but the difference is not as great as for equipment and testing or as modest as for sanitation and operating procedures.

Table 16b shows the food safety, process control index for processing plants with no slaughter operations. Notice that the overall index differential narrows

Table 16b—Technology index for processing plants for five types of food safety technologies[1]

Plant type	Size percentile 0-19	Size percentile 80-99	All plants
	Technology index		
Cooked meat processing, no slaughter:			
Overall tech/methods	0.53	0.64	0.57
Equipment	0.46	0.64	0.55
Testing	0.46	0.74	0.51
Sanitation	0.55	0.55	0.61
Operations	0.61	0.69	0.62
Number of plants	68	73	368
Raw meat processing, no slaughter:			
Overall tech/methods	0.52	0.64	0.55
Equipment	0.51	0.66	0.55
Testing	0.36	0.75	0.55
Sanitation	0.51	0.51	0.51
Operations	0.61	0.68	0.63
Number of plants[2]	65	58	327

[1]Index values derived from Q19-65 in the meat survey and Q20-62 in the poultry survey. See the text for how the index was determined. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.
[2]Two raw meat processing plants have missing rank data.

Source: ERS.

considerably from the slaughter industry. This is mainly due to fewer equipment options available for controlling pathogens. It is also important to observe the sizeable jump in the testing index value as plants grow in size. This rise again illustrates that large plants place a greater reliance on testing.

Market Mechanisms Encourage the Use of a More Extensive Food Safety Technology

Market mechanisms, such as buyer requirements, export inspections, and product brands, have emerged as ways for buyers to better control seller incentives to underinvest in food safety. In each case, sellers reveal their identities, making themselves subject to greater scrutiny for food safety performance, in exchange for greater revenues per pound of meat or poultry or a secure market for their output. Empirically, we should observe a higher food safety technology index rating for plants that are subject to market mechanisms.

Table 17a shows the food safety process control index values for food safety equipment, testing, dehiding (cattle slaughter only), sanitation, and plant operations for three slaughter industries under three market mechanisms. Index values for equipment, testing and dehiding (cattle slaughter only) were nearly twice as high for cattle and hog slaughter plants subject to buyer food safety requirements or engaged in export markets than for plants not subject to these market mechanisms. In contrast to the differences for plant size, sanitation and operations were also distinctly higher for cattle slaughter. Selling products under one's own brand name appeared to have no impact on the food safety technology index. We attribute this to a poorly worded question (discussed earlier). Poultry slaughter plants exhibit similar but more muted differences between plants subject to market mechanisms and those not subject to them.

Meat and poultry processors subject to market mechanisms (table 17b) also have higher food safety technology index values, but differences are restricted to equipment and testing. Index values for sanitation and operating procedures are nearly the same. We attribute this difference from the slaughter industries to the product mix of meat processors. Lawrence et al. (2001) provide evidence showing that most processing plants sell products under brand names or can otherwise be linked to a product purchased by a consumer. So, virtually all of the plants are subject to market mechanisms. Equipment and testing index values may differ because of variations in size rather than because of greater market pressure.

Now consider how these food safety technology ratings square with the results for compliance costs with PR/HACCP. Recall that plants subject to market mechanisms had PR/HACCP compliance costs that were only modestly lower than the costs of plants not subject to market mechanisms. Combining that information with results concerning the food safety process control technology indexes provides evidence that market mechanisms encouraged plants to have process control systems that exceed the PR/HACCP standards. These data also suggest that FSIS required many tasks under the PR/HACCP rule that were different from those prompted by market mechanisms (otherwise plants subject to market mechanisms would have much lower compliance costs with the PR/HACCP rule).

Table 17a—Technology index for slaughter plants for five types of food safety technologies[1]

Process control method	Market mechanism					
	Buyer food safety requirements		Export market		Product sold under plant's own brand[2]	
	No	Yes	No	Yes	No	Yes
	Technology index					
Cattle slaughter:						
Overall tech/methods	0.43	0.63	0.43	0.64	0.52	0.50
Equipment	0.30	0.56	0.28	0.62	0.42	0.38
Testing	0.35	0.77	0.36	0.79	0.57	0.50
Dehiding	0.28	0.48	0.28	0.51	0.41	0.35
Sanitation	0.51	0.61	0.54	0.60	0.60	0.55
Operations	0.58	0.68	0.59	0.68	0.62	0.62
Number of plants[3]	128	98	169	84	43	210
Hog slaughter:						
Overall tech/methods	0.44	0.60	0.44	0.59	0.44	0.50
Equipment	0.32	0.53	0.29	0.56	0.34	0.39
Testing	0.34	0.74	0.36	0.73	0.40	0.50
Sanitation	0.55	0.57	0.56	0.53	0.59	0.55
Operations	0.59	0.64	0.58	0.63	0.52	0.61
Number of plants[4]	106	66	138	68	25	180
Poultry slaughter:						
Overall tech/methods	0.55	0.64	0.49	0.64	0.59	0.62
Equipment	0.57	0.68	0.45	0.68	0.60	0.65
Testing	0.51	0.70	0.39	0.69	0.53	0.65
Sanitation	0.53	0.56	0.49	0.57	0.65	0.55
Operations	0.57	0.61	0.62	0.61	0.61	0.61
Number of plants[5]	29	65	16	94	12	99

[1]Index values derived from Q19-65 in the meat survey and Q20-62 in the poultry survey. See the text for how the index was determined. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.

[2]Products may or may not be sold to consumers. Selling a product under one's own name could be shipping a labeled product to further processor that repackages the meat or poultry under its own name and resells it.

[3]Twenty-nine plants did not indicate customer requirements; 2 plants did not indicate exports; 2 plants did not indicate products under own brand.

[4]Thirty-eight plants did not indicate customer requirements; 4 plants did not indicate exports; 5 plants did not indicate products under own brand.

[5]Fifty-four plants did not indicate customer requirements; 38 plants did not indicate exports; 37 plants did not indicate products under own brand.

Source: ERS.

Table 17b—Technology index for processing plants for five types of food safety technologies[1]

Process control method	Market mechanism: Buyer food safety requirements No	Yes	Export market No	Yes	Product sold under plant's own brand[2] No	Yes
	Technology index					
Cooked meat processing, no slaughter:						
Overall tech/methods	0.51	0.64	0.53	0.63	0.55	0.57
Equipment	0.46	0.65	0.49	0.65	0.51	0.55
Testing	0.47	0.78	0.51	0.78	0.67	0.61
Sanitation	0.55	0.57	0.56	0.56	0.53	0.56
Operations	0.60	0.66	0.61	0.65	0.61	0.63
Number of plants	202	166	230	138	12	356
Raw meat processing, no slaughter:						
Overall tech/methods	0.49	0.62	0.52	0.61	0.56	0.55
Equipment	0.45	0.67	0.51	0.64	0.55	0.55
Testing	0.40	0.72	0.45	0.73	0.55	0.54
Sanitation	0.50	0.53	0.50	0.52	0.47	0.51
Operations	0.61	0.66	0.63	0.64	0.67	0.62
Number of plants	179	148	215	112	30	297

[1]Index values derived from Q19-65 in the meat survey and Q20-62 in the poultry survey. See the text for how the index was determined. Intermediate percentiles not included because they follow a trend established by the highest and lowest rated plants.

[2]Products may or may not be sold to consumers. Selling a product under one's own name could be shipping a labeled product to further processor that repackages the meat or poultry under its own name and resells it.

Source: ERS.

Conclusions

This report uses data from the first national survey of meat and poultry plants on the costs of the PR/HACCP rule and the use of food safety technologies to address issues central to the food safety control efforts made by meat and poultry plants and FSIS. It provides estimates of the expenditures made by the industry both to comply with the PR/HACCP rule and for their own privately motivated food safety investment decisions. It also gives a snapshot of the types of food safety technologies and practices used by the industry. Finally, it provides strong evidence that market mechanisms encourage the use of more sophisticated food safety technologies and an expanded array of food safety practices. The complete survey and the associated summary data can be seen in on the ERS website at: www.ers.usda.gov/data/haccpsurvey/.

The survey provides a substantial amount of data related to PR/HACCP that will be explored more extensively in future studies. These studies will turn to investigation of the perceived benefits of PR/HACCP as well as the long-run costs of PR/HACCP rather than the shortrun costs described here. We will also examine the impact of plant characteristics and food safety equipment and processing practices on plant quality control performance and consider the technological paths plants use to provide food safety.

The Influence of the PR/HACCP Rule

Estimates based on the ERS survey suggest that meat and poultry plants incurred $570 million in fixed costs and $380 million in annual variable costs to comply with the PR/HACCP rule; those cost estimates are much higher than the cost estimate of $1 billion to $1.2 billion spread over 20 years made by FSIS prior to enactment of the regulation. Depending on the useful life of the fixed assets, the cost estimate based on survey data is close to the $623 million in annual fixed and variable costs projected by ERS with an alternative methodology in a previous publication (see Ollinger and Mueller, 2003).[21] Results are also consistent with results from a much smaller survey (Boland et al., 2001) and estimates by Antle (2000). Notwithstanding the higher than anticipated costs of these estimates, projected benefits still exceed industry costs. Crutchfield et al. (1997) provide an estimate of $1.9 billion in annual health savings when using the most conservative valuation technique and assuming 20-percent effectiveness at reducing foodborne illnesses caused by meat and poultry.

[21]Given the nature of the fixed costs, a reasonable economic life of the fixed assets might be 3 to 5 years. If a 3-year life occurred, then the previously estimated costs and costs obtained from this survey are nearly identical.

A major reason why our cost estimate is much greater than that made by FSIS is that FSIS considered only the administrative costs associated with record-keeping and planning, the direct cost of testing, and a small estimate of capital outlays whereas this report includes these costs, the costs of hiring the workers necessary for remaining in regulatory compliance, and the capital outlays necessary to bring each plant up to the standards necessary for compliance with regulatory standards. This broader definition of the costs of the PR/HACCP rule is necessary because regulatory costs should include all costs that a plant incurs to perform tasks that it would not do in the absence of regulation.

ERS survey data suggest that the PR/HACCP rule has raised beef and poultry slaughter plant costs by about one-third of 1 cent per pound. However,

these are average prices per pound of beef and not the average cost incurred by each plant. Small plants, which tend to produce more specialized products, had much higher average costs than the giant plants, which produce mainly commodity products, such as boxed beef. Since plants must recover their costs, this means that prices for commodity products will rise very little, while prices for more specialized products, like cut-to-order beef, may rise as much as 2 or 3 cents per pound.[22] In terms of industry structure, small plants that produce specialty products probably will not be affected that much by PR/HACCP because they have some pricing flexibility, but small plants producing commodity products may face stiffer cost pressures, causing some to exit the industry. From a policy perspective, these plant exits and higher costs are acceptable if the expenditures for food safety are needed to better control pathogens.

Taken at the surface, it appears that compliance costs as a percent of the total cost of production are lower for beef and pork than for poultry since beef costs about twice as much to produce as poultry, as shown by Antle, 2000. However, since many of the beef and pork products must also be further processed but poultry does not, one should add raw and cooked meat processing costs to the slaughter costs. After making this adjustment, survey data suggest that beef and pork costs would rise by about three-fourths of 1 cent per pound—about twice as much as poultry, but about the same as a percentage of costs.

There are some other indirect costs and benefits associated with the PR/HACCP rule. We cannot say whether, on balance, these other factors increase or decrease costs. ERS survey results suggest that product shelf life increased at about 25 percent of all meat and poultry plants. However, plants also suffered additional costs due to declines in production yields and increases in production downtime.

The cost of the PR/HACCP rule is a substantial sum, but it is still much less than the cost of irradiating meat and poultry, which kills all harmful pathogens and is one way to ensure pathogen-free meat or poultry. For example, irradiated ground beef costs 10 cents to 30 cents more—a 5-percent to 10-percent price premium—at Wegmans Food Markets in Pennsylvania by the *Lancaster Farming* newspaper in October 2002.[23]

The ERS survey also provided information about the components of the PR/HACCP rule perceived to be most beneficial for pathogen reduction and the aspects considered to be most costly. More plants in all industries except poultry slaughter, regardless of size, believed that the SSOPs had the greatest impact on pathogen reduction, yet very few plants perceived them to be the most costly. A large number of plants also said that HACCP plans and their use had a substantial impact on process control, but a much larger number felt that the use of a HACCP plan was the most costly aspect of the PR/HACCP rule. Many plants also felt that the zero fecal matter/*E. coli* standard is one of the most important aspects of the PR/HACCP rule for pathogen control and a similar number of plants felt that it is the most costly. On balance, these data suggest that plant operators believe more stringent SSOPs are the most cost-effective way to achieve pathogen reduction and HACCP plans are the least cost-effective. HACCP recordkeeping requirements appear to be particularly troublesome for operators. (See box.)

[22]Actual price increases seen by consumers depend on a number of factors. First, retailers may choose to either mark prices up more or less than its cost increase. Second, long-term demand for the product can change, altering consumers' willingness to pay a higher price. Third, price increases in one product encourage buyers to consider the purchase of alternatives, resulting in greater product price pressure.

[23]The irradiation process does heat treat the meat or poultry product, so, technically, ground irradiated meat is not the same as ground unirradiated meat. Price premiums also depend on tradeoffs between taste and safety. Many consumers prefer the taste of unirradiated meat to irradiated meat and may actually demand a price premium for unirradiated meat. Under these conditions, retailers may not even choose to sell irradiated products because the extra processing makes the meat or poultry more costly to produce. Note also that producers of irradiated products still have to comply with the PR/HACCP rule.

Comments Provide Operator Insights into How To Shape the PR/HACCP Regulation

A number of the survey respondents (43) expressed their views about the PR/HACCP rule in written comments. In general, these comments and data reported in this report show a general acceptance of three components of the PR/HACCP rule—SSOPs, zero tolerance for fecal matter/generic *E. coli* testing, and the *Salmonella* standard. Only the requirement that all plants maintain and implement a HACCP plan drew a substantial number of negative written comments. A disproportionately larger number of plants commented that the plan requirement was the most costly aspect of the PR/HACCP rule, compared with the number of plants that answered that the requirement was the most beneficial part of the rule.

A large majority of the written comments said that the HACCP plans and tasks were necessary. Indeed, about 25 percent said that a HACCP program improved their process control performance and only about 10 percent said HACCP provided no benefits or the tasks themselves were too costly. The chief complaint was about the additional paperwork burden (both record-keeping and HACCP plan development) and inspector inconsistencies. About 60 percent of the responses said that the paperwork costs outweighed the benefits of the HACCP tasks and about 25 percent said that inspector inconsistencies of enforcement led to much higher costs.

It is quite natural to expect the processing-plant operators who are most negatively affected by the HACCP/PR rule to express complaints, but small-plant operators may have a point. A large number of plants inspected by FSIS have fewer than 10 employees, and the plants produce numerous products in small batches. Under these small-batch/multiproduct operating conditions, plants have frequent product changeovers and short production runs that may never reach a steady-state condition. Yet, process control programs such as a HACCP plan monitor production flows, implying that fewer and fewer benefits are realized for shorter and shorter production runs. Moreover, even as the benefits of HACCP programs diminish for multiproduct plants, the costs rise because, for each product, separate HACCP plans may have to be written, records may have to be maintained, and it may be necessary to monitor different points and follow different procedures. Thus, the smallest plants, which often have very complex product mixes, face very high costs; yet, may have staffs of two or three workers and low revenues, making the record-keeping costs per dollar quite high.

Formalized HACCP plans may also be less necessary in small plants. Top management is much better able to directly monitor quality in a small plant than in a large one because top management is often performing manual product processing tasks, performing cleaning and sanitation, and directly handling the product. In larger plants, by contrast, recordkeeping traditionally has been and continues to be essential for maintaining food safety process control since this is the only means a top manager has to monitor food safety. The perverse result is that costs of developing and implementing HACCP plans are higher in small plants; yet, these plants have the most direct control over production by top management.

Survey responses suggest that operators are supportive of performance standards. Yet, testing is much more costly for smaller plants than for larger ones because many larger plants have their own laboratories with a specialized workforce and do testing as part of a daily routine. Thus, government support

may be necessary if extensive testing for *Listeria monocytogenes*, *E. coli* O157:H7, or other pathogens becomes mandatory. The alternative would be disproportionately higher costs for smaller plants relative to larger ones.

Despite the costs of the PR/HACCP rule, some plants invested still larger sums in food safety, presumably because their customers demanded it. Buyer and export market requirements and product branding are among the market mechanisms that encourage producers to enhance food safety process controls. This report shows that plants subject to market mechanisms, particularly buyer and export market requirements, used a more sophisticated food safety quality control system than other plants, while at the same time incurring compliance costs similar to those incurred by other plants.

Food Safety Technology and Practices

Plant size and product markets played a major role in the types of equipment and processing practices employed by meat and poultry plants. To measure the differences, we created five indexes of food safety plant technology for each of the five technology categories: equipment, testing, dehiding, sanitation, and plant operations.

Index values, which ranged from 0 to 1, varied substantially across plants. Large plants typically relied on sophisticated equipment and testing while smaller plants tended to focus more on SSOPs and plant operations. Plant size also played a role in the types of changes plants felt best controlled pathogens. Larger plants tended to place much more emphasis on the purchase of new equipment and changes to facilities while smaller plants tended to focus more on the frequency of cleaning and product flows. This makes a lot of sense. More than one-half of all plant managers believed that equipment and plant facilities changes were most costly. Since this requires a fixed investment and since larger plants have the capacity to make full use of it while smaller plants may not, large plants could realize much lower per-unit costs.

A central theme of this report is that market mechanisms encourage food safety investments.[24] Retail and restaurant customers of meat and poultry plant products and government inspectors receiving exported meat products are in a better position than consumers to ascertain the food safety of the products that they receive because they can conduct microbiological testing and impose production standards on their suppliers. Cost information from the ERS survey supports the market effect hypothesis. Plants subject to stricter market mechanisms had much higher food safety index values than other plants for equipment and testing and higher but less robust differences in SSOPs and plant operations.

The role played by markets in imposing strict food safety standards on meat and poultry producers has important public policy implications. It suggests that information about plant food safety performance provided by FSIS, such as plant quality control performance ratings, could be used by meat and poultry buyers in their purchasing decisions, and may encourage greater diligence in performing food-safety-related tasks and elicit greater investment in food safety technologies.

[24]The level of investment required through market mechanisms may or may not be the socially optimal level. Since the optimal level cannot be precisely determined, buyers could demand a level of food safety that costs more than the benefits in improved health. On the other hand, buyers could demand less food safety than optimal, suggesting that underinvestment exists. Regardless of whether buyers demand a level of food safety that is greater, less than, or equal to the social optimal level, it appears certain that the buyers acting through market mechanisms demand greater food safety than that offered under PR/HACCP.

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AMERICAN MEAT INSTITUTE

AMERICAN ASSOCIATION OF MEAT PROCESSORS

NAMP

Date: August, 2001

To FSIS Contact:

The U.S. Congress has requested a report assessing the costs incurred by the meat and poultry industry of implementing and administering the HACCP/Pathogen Reduction rule (the rule), which was promulgated in 1996. Your participation is essential for providing accurate information.

The Social and Economic Sciences Research Center (SESRC) of Washington State University will gather the information for analysis by the Economic Research Service, an agency of the U.S. Department of Agriculture. SESRC has been advised to contact you because you may the one best able to respond to questions about the costs of the rule. So, please take a few minutes to complete the attached questionnaire.

The information you provide will not be used as individual data about your operation, but rather will be combined to show overall costs and trends regarding the implementation of HACCP in your plant. Thus, the results will aid in the understanding the true costs and effectiveness of the inspection system in plants like yours. It could also help influence or affect the way future changes are made in the inspection program requirements.

Again, your cooperation is appreciated. Thank you in advance for your consideration.

Sincerely,

Mark Dopp
Senior Vice-President for
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American Meat Institute
(AMI)

Bernard F. Shire
Director, Legislative and Regulatory Affairs
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Marty Holmes
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